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SOME FUNDAMENTAL PHYSICAL FACTORS IN THE PROBLEM OF THE CONTROL OF THE ATMOSPHERIC ENVIRONMENT.

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The problem of ventilation, as we conceive it today, is but a part of a much bigger problem which deals with the effect of the environmental atmospheric conditions upon the health and comfort of the individual. The full solution of a problem of this magnitude and complexity necessarily involves a separation into factors.

These are for example, the engineering and mechanical factors. These are capable of complete solution although progress is still possible in the direction of economies. Air conditioning, however, is now an established engineering science and the engineer is prepared to supply any kind of air that is desired.

Then there are the physiological factors, or the response of the organism to various conditions. Here our knowledge is less definite and has not advanced beyond a general conception that there are certain conditions which make for comfort and certain others which do not; and some approximate, qualitative idea of the influence of temperature and humidity upon physiological functions. Here again separation into simple factors is necessary and our failure to get quantitive measure of the actual relationship is due to the confusion of too many independent variables.

The primary physiological function with which we have to deal is the dissipation of heat from the body. In its physiological aspects this function is complex, but in its physical aspects it is extremely simple.

dissipation is accomplished by evaporation of moisture, by direct heat transfer to the surrounding cooler air, and by direct radiation to a nearby cooler surface, or by a combination of two or more of these. The second or the third factor may be negative in its action, *i.e.*, may actually warm the body and all three may vary quite independently; but physiology demands as a net result, that the sum total of these three kinds of heat interchange shall have a certain determined value. If this becomes physically impossible fever and collapse follow. Short of actual collapse, however, there are manifestations of discomfort which record the attempts of the body to adjust itself to the environmental conditions and to maintain the necessary heat dissipation, while within a still more restricted range such adjustment is accomplished without discomfort. If there were but one variable physical factor, or if the several factors were mutually dependent variables, or again if they were independent in their physiological effect like two distinct kinds of poison, then the problem of delimiting the three regions of normal adjustment, adjustment with discomfort and total failure of the adjusting mechanism would be capable of a simple experimental solution. Unfortunately neither of these assumptions holds. There are three methods of heat dissipation; evaporation, direct transmission and radiation. They are mutually independent as physical variables but affect the body in the same way.

For example it is not possible to state that any particular rate of evaporation is essential to comfort. In a cool air heat is transmitted to the air and evaporation is reduced, but equal comfort may be experienced in a warmer air with less transmission of heat and a compensating increase in evaporation.

These considerations show that anything more than an empirical solution of the major problem involves of a necessity a complete analysis of the inter-relationship of these three modes of heat transfer. The present discussion is an attempt to make such an analysis. It will first be necessary to reduce the three factors to still more simple and fundamental terms.

Looking at the matter now from a purely physical point of view evaporation is a function which depends upon (a) the capacity of the environment to receive additional moisture, and (b) the rapidity with which evaporated water is removed from the immediate environment. In turn (a) depends upon the temperature of the air and upon the amount of moisture already present (humidity) and (b) upon the velocity of movement of the air over the moist surface.

Direct transmission of heat to the surrounding air depends upon (c) the temperature of the air, (d) its heat capacity, (e) the volume of air brought into contact with the warm surface per unit of time and (f) the coefficient of diffusion of heat through the air. The relation of factor (c),

the temperature, is obvious, since the rate of heat transmission between two bodies is proportional to the difference in their temperatures. Factor (d), heat capacity, is readily illustrated by comparing air cooling with water cooling, the temperature of the two media being the same. The heat capacity of air depends in turn upon the humidity. Factor (e) shows one method (convection) of getting the heat away from the warm surface, *i.e.*, by removing the heated air. It depends upon the velocity of movement. Factor (f) shows a second method, (conduction); it depends upon temperature and humidity.

Radiation is in general of minor interest but in especial cases, direct sunshine for example, it is of some importance. It depends upon the temperature and distance of the warm or cool object.

Summarizing now this analysis, we have the following relationships, each factor in the scheme depending upon those subordinate to it:

MODES OF HEAT LOSS.

A. *Evaporation.*
- (a) Humidity (departure from saturation).
  - Temperature.
  - Humidity (actual).
- (b) Removal of moisture.
  - Velocity of air movement.

B. *Transmission of Surrounding Air.*
- (c) Temperature.
- (d) Heat capacity of air.
  - Humidity.
- (e) Volume of air per unit of time.
  - Velocity of movement.
- (f) Coefficient of diffusion.
  - Temperature and
  - Humidity.

C. *Radiation.*
- (g) Distance of object.
- (h) Temperature of object.

While the inter-relations are somewhat complex, one is struck with the fact that leaving out of consideration the radiation factor all the others finally reduce to three, temperature, humidity, and velocity of movement of the surrounding air. We have to consider also the temperature and distance of the nearest solid mass. Moreover it is apparent that any one of these may be varied and a corresponding change made in any other one so as to compensate for the first change and maintain the heat loss constant. It is also seen from the analysis that the inter-relations of the three funda-

mental physical constants are very complex. Humidity and temperature each enter the analysis in three different and independent ways and velocity of movement enters twice. The full solution, therefore, requires an extensive investigation under controllable conditions and a determination of the relation of each variable to the total result, the other variables being maintained constant.

This is the scope of a laboratory investigation which was begun a year ago at the Sanitary Research Laboratory of the Massachusetts Institute of Technology, and is being continued this year in coöperation with the New York Commission on Ventilation.

We have undertaken to determine as a first step in the solution of the major problem, the rate of heat loss from moist warm surfaces under all conditions of humidity, temperature, and velocity of movement. The experiment is so planned that each of the three fundamental variables may be studied by itself over a wide range, the other two meanwhile being held constant.

VENTILATION INVESTIGATION.

D. D. KIMBALL.*

Read before the Section on Vital Statistics, American Public Health Association, Colorado Springs, September, 1913.

In a paper presented by the author at the meeting of the American Society of Heating and Ventilating Engineers in January, 1912, the phases of ventilation demanding most serious study were summarized as follows:

1. Volume of air. Our present standards are questioned. By a proper study of temperature or humidity could they be decreased or should they be increased?

2. Temperature. Our present standard (68° for the school room and home) is said to be too high. Shall it be lowered and, if so, to what point?

3. Variation of temperature. A periodical reduction of temperature is said to be desirable.

4. Humidity. Is artificial humidification of occupied apartments desirable, and, if so, to what degree?

5. Movement of air. This is said to be desirable. When can it be employed and to what extent can it be carried without involving injurious drafts? What of a frequent "flushing out" or perflation?

6. Heating of air. May the air be harmed or in any way affected in the process (assuming the air to be free from dust)?

7. Cooling of air. Is this desirable in occupied apartments and will it involve undesirable attending features?

8. Dust. It is stated that dust is extremely harmful. What is its effect, how best eliminated, and how generally should such means be employed?

9. Organic matter from the breath or body. Its nature and effect.

10. Chemistry of the air. Is there anything connected therewith worthy of further investigation? What of ozone?

11. Relation of ventilation to exercise and work.

12. Methods of determinating the effect of ventilation and its different elements upon the individual.

A consideration of what has been done towards the solution of these problems and of tests and investigations which have been and are being conducted looking to the solution of these problems is most interesting.

A conference on the subject of ventilation held on the evening of August 26, at the Hotel Iroquois at Buffalo, in connection with the Fourth International Congress on School Hygiene, brought out some interesting conclusions as to the different phases of the problem of ventilation.

This meeting was attended by forty men prominent in ventilation in-

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vestigations and the subject was thoroughly discussed in all its varying phases. As to air volume, it seemed to be the consensus of opinion that the volume of air in itself was not an important factor in ventilation but that a certain volume of air was essential in densely occupied rooms for the elimination of heat and moisture and for the maintenance of air movement. It also seemed to be generally agreed that ventilation bears no relation to respiration.

It was generally agreed that oxygen, within the limits usually found in connection with ventilation work has no practical bearing on the problem of ventilation.

It was agreed, also, that CO_2 has no special importance in connection with this problem. There are those, however, who still regard it as a reliable index to the ventilation of the air and an index of the extent of air renewal.

There can be no doubt that when CO_2 is found present in the air of a moving picture theatre in the proportion of 42 to 70 parts in 10,000, as has been found in the Chicago theatre investigations, this may be regarded as satisfactory indication that the air supplied is seriously deficient.

On the subject of odors there seems to be no authority for regarding odors as harmful, but for æsthetic and psychological reasons it is agreed that odors should be eliminated from the air used for breathing.

As to organic matter, at present it seems to be regarded that the possible harmfulness of organic matter from the breath of body is not proven, the burden of proof resting on those who feel or claim there may be harm therein.

On the subject of bacteria, it is now agreed that there is little or no danger of ærial infection and that ventilation will in no way lesson the danger of infection. At the same time, Haldane's showing of 256 bacteria per cubic foot of air in an unventilated room compared to practically none in the ventilated room is worthy of serious consideration.

As to dust, while it is agreed that it is desirable from an æsthetic point of view that the air for breathing purposes should be free of dust, there is no agreement as to the exact effect of dust on its danger to health. There are those who feel strongly that it is a serious element of danger and this problem should be cleared up.

The much discussed question of humidity still remains undetermined although there seems to be an approach to an agreement that a relative humidity of less than 30 per cent. or 35 per cent. is injurious and that a relative humidity of 50 per cent. is as high as is desirable, although a relative humidity as high as 70 per cent. with a temperature of 70° involves no harm. In this connection tests made at Lewis Institute in Chicago are noted as evidencing the effect of humidity. In these tests it was found

that with a humidity of 25 per cent. the pupils were alert for the first part of the first hour and then became stupid. With the humidity raised to 45 per cent. to 50 per cent. the efficiency of the pupils returned. When the humidity was raised beyond this point the pupils again became stupid and headaches developed.

In connection with the subject of humidity it is agreed that humidity and temperature are intimately linked together and that the question of temperature may not be determined independently of the question of humidity. However, there seems to be a general agreement that the temperature standards of the past have been higher than are desirable. The generally accepted modern standard for school-room work seems to be tending toward 65°. Dr. J. H. McCurdy seems to have established that for gymnasia work the desirable temperature is 60° to 61° with 50 per cent. relative humidity.

There seems to be very little disposition to dispute Doctor Gulick's suggestion that a variation of temperature is as desirable inside of buildings as in the outside atmosphere. The necessity of movement of air is entirely agreed to as being essential to the removal of the body envelope of hot moist air.

At the conference above referred to, in connection with the discussion on humidity, Doctor McCurdy raised the question as to whether the expired air was saturated and at body temperature under all conditions of outside temperature and humidity. Also as to the effect of dry air on the membrane of the respiratory passages. This question was not answered at this conferene, and may have such bearings on the question of artificial humidification as to make it worthy of serious study.

The opinion was given that human beings could not live in an atmosphere of 89° or 90° wet bulb temperature or above.

The use of ozone in connection with ventilation work, especially for the purpose of destroying odors is receiving more attention than heretofore. There seems to be no evidence of any intention to claim anything more for ozone than its value as a method of eliminating odors. The quantity of ozone recommended for this purpose is 20 milligrams of ozone per hour for the average mechanic and 16 milligrams per hour for a school pupil.

The interest manifested at this time in the study and investigation of the problems of ventilation is most encouraging and augurs well for an early solution of this important problem. It seems especially desirable at this time that a collection and correlation of all of the data secured in the investigations which have been and are being made should be undertaken. Such a coöperation would do much to clear up the misunderstandings and doubt surrounding this question. For this purpose, the offices of the newly appointed New York Ventilation Commission are volunteered.

It is probably the only investigating body now at work on this problem

which is provided with means (both in a financial sense and in the sense of having a sufficient organization) to properly carry out such a plan and to carry on investigation and research work aiming to prove or disapprove the varying theories advanced, and to undertake such further experiments or investigations as may be necessary to fill in the voids between experiments previously or concurrently made by other investigators, or to do such other experimental and research work as may be necessary to complete the solution of a many sided and perplexing question.

Through the generosity of Mrs. Elizabeth Milbank Anderson, the New York Association for Improving the Condition of the Poor has been provided with a fund of $50,000, or such a portion thereof as may be required, to cover the expense of a thorough study and investigation of this problem. At the suggestion of this association Governor Sulzer appointed the following gentlemen as members of the commission: Prof. C.-E. A. Winslow, Prof. F. S. Lee, Dr. J. A. Miller, Prof. E. L. Thorndike, Prof. E. B. Phelps, D. D. Kimball.

The problem involves public health, psychological, medical, physiological, laboratory and engineering phases, and, therefore, an expert in each of these branches is included in the make-up of the commission.

An office of the commission and laboratories have been secured at the College of the city of New York. Two adjacent rooms are available, one of which is to be used as a control room and the other as an observation room, although subjects under observation may be placed in either or both of the rooms, with the same or different atmospheric conditions in the two rooms.

These rooms are inside rooms, lighted from the ceiling, so located as to be entirely unaffected by outside weather conditions. In the control room there is now being installed a complete model or experimental ventilating plant, including a motor-driven fan supplying fresh air which is to be taken in through the roof. From this fan the air will pass over heating coils and thence through an air washer and humidifier, or through a dryer, and from either of these devices, as desired, or in mixed quantities from both, the air passes over reheaters which may or may not be in operation, and thence into the two rooms. The system is divided into two parts, each part serving one of the rooms, so that the atmospheric conditions in the two rooms may be different or the same, as willed, for the purpose of making comparative tests. Temperatures ranging from that of out-of-doors to 100° in zero weather and humidities ranging from nothing to saturation can be provided in these rooms.

The air may enter or be exhausted from the observation room at any or all of four levels in the height of the room.

Another fan, with direct connected motor, is provided for maintaining an exhaust from both rooms. This may discharge out through another

portion of the building or back into the intake duct for tests on recirculated air.

Speed control devices are provided in connection with the motors, so that any quality of air may be supplied or exhausted, from 800 cubic feet per minute (400 for each room), down to practically nothing.

An elaborate system of automatic temperature and humidity controlling devices is provided to maintain any desired temperature and humidity conditions in both rooms.

Provision is also made for the installation of disc fans to provide air currents as desired.

Provision is also made for the introduction of ozone or ozonized air at various points of the system or directly into the rooms. Observation and measuring openings are provided.

The system is so arranged that there may be readily combined therewith a cooling plant for experimentation in artificial cooling.

The atmospheric conditions in the observation room will be controlled entirely from the control room. Direct means of communication are provided between the two rooms.

A complete outfit of instruments is being provided, including several Petterson and Palmquist CO^2 determining machines (Roger's modified pattern), sling psychrometers, wet and dry bulb thermometers (direct reading and recording), Pitot tubes, anemometers, ergometers, etc.

Auxiliary to the above apparatus three animal cages are provided, two to be located in the observation room, and one in the control room, so arranged that different atmospheric conditions may be maintained in each.

This plant will be used in an effort to determine the effect of any possible chemical or physical condition of the atmosphere upon human or animal subjects. Both physical and psychological effects will be measured, mental and physical tests being applied. Blood pressure, pulse and respiration rates, bodily temperature and other desirable measurements and records will be made.

Supplementary to the work done in this laboratory other experiments will be conducted in a respiration calorimeter to be constructed by the commission at the College of Physicians and Surgeons.

For the purpose of a practical application of the results of the experiments above contemplated arrangements have been concluded to install an experimental ventilating plant in two rooms of a new school building in New York. These rooms will be so arranged that air may be supplied through the ceiling or floor, immediately at the desk, or through either of two of the walls of both rooms. Likewise, the air may be exhausted through floor or ceiling or through either of the two walls. Window ventilation may be tested here also. Two similar rooms occupied by a similar class of pupils will be used as controls.

In coöperation with this commission, Dr. J. H. McCurdy, at the International Y. M. C. A. College, at Springfield, Mass., will continue and extend his experiments of the last two years with recirculated air. Also Professor Phelps will continue at the Massachusetts Institute of Technology his experiments upon moisture elimination and absorption, the effect of different clothing materials, and the study of other physical problems. Other tests and experiments in coöperation with the commission are being arranged. Open air school and hospitals will be studied.

This commission seeks and offers coöperation from and with all who are investigating this important problem. It is believed that much time may be thus saved in reaching satisfactory results, and that the work of every investigator will be greatly facilitated.

During the last two years a most interesting and extended experiment upon the use of recirculated air has been conducted at the International Y. M. C. A. College, under the immediate supervision of Dr. J. B. McCurdy, and Prof. G. B. Affleck. During the heating season of 1912–13 a serious effort was made to cover as many phases of the problem as possible. To this end a voluntary association was formed to coöperate with Doctor McCurdy and Professor Affleck, including Prof. G. C. Whipple, Mr. M. C. Whipple, Prof. C.-E. A. Winslow, Mr. C. E. Pearce and the author. The air, when recirculated, was passed through an air washer and special attention was given by Mr. Whipple to chemical and microscopical studies of the water and air. Mr. Whipple performed a vast amount of work, both at the college and in his laboratory at Harvard University, the results of which he can give in detail.

Messrs. Horne, Knapp and Geer, seniors at the college, gave valuable assistance throughout the season by making and recording carbon dioxide, temperature and humidity tests, and also "comfort" records of the students. Some very conclusive data as to the most comfortable atmospheric conditions in gymnasia were obtained.

While it may not be stated as a result of these investigations that the recirculated air, when washed, is as good as outside air when washed, it is apparently better than outside air unwashed, being freer from dust and bacteria and not appreciably less in oxygen or higher in carbon dioxide. Increased efficiency in air washing apparatus will improve the quality of the recirculated and washed air.

The fact that the use of recirculated air for ventilating purposes (assuming that its quality is found to be entirely suitable) makes possible a reduction in coal consumption of approximately two thirds or, in other words, makes ventilation possible without greater expenditure for fuel than that required for direct heating without ventilation, makes the study of recirculated air a most worthy one. Such a reduction in operating costs would eliminate one of the serious objections to the artificial ventilating system.

The cost of installing the ventilating system is practically the same whether the air be recirculated or not.

Another set of most interesting tests of the possibilities of recirculated air is that of Professor Bass of the University of Minnesota, made in the Jackson School in Minneapolis.

Extensive investigations in ventilations have been conducted during the past year by the Chicago Ventilation Commission.

It is interesting to note from the conclusions of this commission in connection with its investigations into theatre ventilation that they regard 25 cubic feet of air per person as a minimum which will give satisfactory results in theatre ventilation; that the amount of moisture in the air in a theatre never becomes low enough to require artificial humidification; that temperatures from 55° to 75° is neither uncomfortable nor injurious; that the number of dust particles is inversely proportioned to the amount of fresh air supplied; that ordinary air washers removes from 20 per cent. to 70 per cent. of the dust; that the so-called convection currents arising from the bodies of occupants may be disregarded with mechanical ventilation, and that exhaust systems of ventilation are of value only in connection with a positive air supply.

Among other experiments made or contemplated may be mentioned those on ozone in the Schenectady schools; a few tests on school-room ventilation in Boston, New York, Toledo and elsewhere; tests on factory ventilation by Dr. C. T. Graham-Rogers, and the extended study made by Professor Winslow and Professor Baskerville on existing atmospheric conditions in New York City schools, these studies covering both the artificially and naturally ventilated school-rooms. In connection with these studies it is to be noted that the best of the artificially ventilated rooms was found to be as good or better than the best of the window ventilated rooms. Every school-room may, with a proper equipment and a good janitor for the building, be kept at all times as well ventilated as the best ventilated room found, while weather conditions, varying winds, and the impossibility of securing proper attention on the part of the average teacher to the matter of ventilation, in addition to other duties, makes impossible satisfactory ventilation by means of windows, except in rare cases. It should be vastly easier to get one man per building capable of operating a ventilating plant than twenty to fifty teachers.

One of the most important, perhaps the most practical if not the most serious, phase of the problem of ventilation, rarely receives consideration in gatherings of this nature, is little appreciated by the student or investigator of ventilation, and of it probably little is known by those most concerned or those directly responsible for school building construction. It is a fact that the chief reason for the failure of the artificial ventilating system is not lack of information as to desirable atmospheric conditions or the

inability of the engineer to provide the same, but the attitude of the school boards, building committees and school architects towards the matter of a sufficient expenditure for a complete ventilating plant.

The first responsibility lies with the school boards or their building committees because of their failure to see that the sum allowed for the ventilating plant is sufficient to give the best that science can devise; to see that the architect does not use any of the money which should be spent on the ventilating plant in the enlargement or ornamentation of the building. Criticism of the architect is not intended in the statement that in not one school building in ten is the engineer allowed to work out what he knows to be the best possible ventilating plant for the building. The vast majority of plants are the result of a compromise (some of them very poor ones from the standpoint of the engineer) between the request of the engineer for freedom to design the right thing and the insistance of the architect (who is usually in charge of the work) that the amount allowed for ventilation shall be the very minimum so that he may meet the demands of the committee (often most unreasonable) for more space or equipment than can be properly provided for the appropriation granted.

The engineer is very often obliged to put one radiator in a room where two or three would be much better; is usually obliged to omit air washers and humidifying systems; sometimes is obliged to omit temperature controlling devices, and frequently is obliged to use inferior materials. And all to enable the architect to give to the board a building as big as he promised, or as big as some other architect offered, or a building as big or pretentious as the citizens expect, or a building as cheaply built per cubic foot as some other supposedly "similar" building in the same, or a neighboring city.

Similarly, through the employment of cheap janitors, many good ventilating systems are rendered inefficient. The employment of capable janitors, paid proper wages, will not only bring about the better operation of the plant but a sufficient reduction in fuel costs to more than pay the increased salary.

Unless the authorities can be made to see the seriousness of these phases of the problem and these difficulties can be eliminated, all of the good work in investigations which is being done will go for absolutely naught, for if the schools do not now get the best that may be had, what hope is there that they will get better when better becomes known?

AN EXPERIMENT WITH OZONE IN SCHOOL VENTILATION.

FREDERIC BASS.

Read before the Sanitary Engineering Section, American Public Health Association, Colorado Springs, September, 1913

The purpose of this paper is to briefly give the data and results of an experiment in school ventilation, using apparatus which was described before the Engineering Section of the American Public Health Association at the last annual convention and published in the April number of the Journal.

The apparatus used may be briefly described as follows: A typical school room on the first floor of a fifteen-room building was selected. The air delivered to the room was taken through a window in the basement, passed over tempering coils through an air washer, thence through heating coils or a by-pass and blown to the room by a fan. The air was delivered into the room through inlets located at the front of the top of each desk, thus giving each pupil an individual supply of air. The velocity of the air at the center of the jet where it came in contact with the body of the pupil was about one and one-half linear feet per second. Air was also admitted to the room along the top of the blackboards. The air was removed at the ceiling through multiple outlets connected with an exhaust fan. It was possible to exhaust this air to the outside or return it to the room.

It was determined to experiment upon the effect of recirculated air in connection with the use of ozone, so the air returning from the room was treated with ozone in the proportion of one part of ozone to one million parts of air. During the test the quantity of air furnished amounted to approximately 8.5 cubic feet of air per minute per pupil. The characteristic odor of ozone was barely perceptible in the room, and apparently kept the air in an acceptable and pleasant condition, for there was no complaint on the part of the teacher or the pupils who were perfectly satisfied with the condition of the room, and who did not know that the air was being recirculated. Upon entering the room from the hall of the school, one would notice the ozone rather than the unpleasant odor usually present. After being in the room for a few moments, one became accustomed to this odor as to any other; however, upon returning to the hall, the distinctive school house odor was quite noticeable.

A group of pupils in the room described was selected for physiological and psychological tests. A control group of pupils of the same grade and general characteristics of race and living conditions was selected in a nearby school, where the ordinary fan system was delivering about thirty cubic feet of outside air per minute per pupil.

Physical records, including measurements of air volumes, temperatures and humidities, were kept. Physiological observations included bodily temperatures and blood pressures. Psychological tests, consisting of division, substitution and motor tests, were made.

The pupils were examined at the beginning and at the end of a three weeks' run, each time the averages of three days' observations being taken. The results of the study indicate that there was no significant difference in the physical or mental progress of the two groups of pupils. The physiological examinations, although performed by a competent physician, were insufficient in scope and proved nothing. The psychological tests, however, were carefully analyzed and found to be well suited for an experiment of this character. The problems in short division involved a high type of selective thinking and memory processes. The substitution tests were partly mental and partly motor. The motor tests consisted of a movement of the index finger, the number of movements being registered in a specially constructed ergometer. The work done in these tests was examined with reference to total amount, rate of improvement and rate of fatigue, and in all respects the work of the test group showed a parallelism with that of the control group. One interesting discrepancy was noted during the tests. The work in division showed a 64 per cent. improvement in the test group against a 25 per cent. improvement in the control group. The other tests did not seem to warrant this improvement and upon examination it was found that the test group was being coached by the teacher who knew that some sort of competition was on, and wanted to be sure that her pupils were going to win out.

The conclusions to be drawn from these tests are interesting. It was shown that under the conditions of an average school house it was possible to recirculate and renew the air for three weeks with satisfactory results from æsthetic and hygienic standpoints.

The average temperature of the room was 68.8 degrees F.; the humidity averaged 32.6 per cent. The air was kept in motion and was free from disagreeable odors, and the room was perfectly comfortable at all times except upon one occasion when the small fan supplying ozone to the room failed and the difference was immediately noticeable, for the teacher soon called attention to the fact that something was wrong with the air, although she did not know the cause. Apparently the ozone was an important factor in keeping the air of the room in a comfortable condition.

No particular attempts were made during this test to control the humidity which was fairly constant and moderate at all times, but the temperature of the room was controlled by thermostats. There was in this room an undetermined amount of air leakage possibly amounting to as much as two changes of air per hour, which is not an unusual amount, but this would be operative irrespective of the type of ventilating system em-

ployed. Recirculated and renewed air would, of course, be impossible with slight difference of inside and outside temperatures unless the windows were raised, but the differences of inside and outside temperature amounting to thirty degrees and upward, recirculation of the air, judging from the results here obtained, is apparently as good a method of ventilation as the use of outside air, provided proper control of the condition of the air is exercised. The most important reason for recirculating air is that of economy and this factor would be most important in a cold climate.

Particular attention should probably be given to the fact that each occupant of the room was furnished but 8.5 cubic feet of air per minute, as against 30 cubic feet of air per minute in the other building. This reduced quantity of air was possible only on account of the method of distribution by means of which each pupil was certain to receive his proper portion of the air and that direct from the inlet into the room. If recirculated air were to be used with the standard system of ducts, that is to say, with a single inlet and outlet into the room, a larger quantity of air would undoubtedly be necessary.

It would seem to the writer that the time has come when the old standards of ventilation and methods of ventilating practice resting primarily upon quantity of air should be replaced by new standards depending upon quality of air and methods of distribution in the room.

Note: Since writing this paper, several articles on the physiological effect of ozone have been published. Attention has been directed to the fact that the ozone probably has the effect of masking odors rather than destroying the cause of the odors. The injurious effect of ozone in high concentrations is also pointed out, as well as the possibility of an injurious effect from the long continued use of ozone in low concentrations. Two interesting papers are: Konrich, Zeitschrift für Hygiene, vol. 72, p. 476; and Jordan and Carlson, Jour. A. M. A. September 27, 1913.

In the experiments conducted by the writer, no injurious or unpleasant effects were experienced by the occupants of the room in a period of three weeks.

SOME PRELIMINARY STUDIES IN AIR WASHING AND ITS RESULTS.

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and

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Read before the Sanitary Engineering Section, American Public Health Association, Colorado Springs September, 1913.

Clean air in motion and of proper temperature and humidity is necessary to indoor comfort. This is, perhaps, as succinct a statement as can be made of atmospheric requirements according to modern views. Our concepts of ventilation are undergoing a change. Slight reductions in the amount of oxygen or slight increases in the amount of carbonic acid in the air we breathe are no longer feared. The human body can automatically adapt itself to slight changes in the proportion of these gases. It is more difficult for the body to adapt itself to temperature changes and these may cause more or less discomfort and damage. The heat relations of the body are complicated, involving heat production within the body, affected by food and by physical and mental exercise; heat transference within the body from the interior to the surface; and heat elimination at the surface, for human beings live normally in an atmosphere cooler than the body. Heat elimination is itself a complicated matter: it is lost by conduction, by convection, by radiation; it is affected by the temperature and humidity of the air, by the clothing worn, by the perspiration produced and evaporated. So complicated are these relations that we have not yet solved them. We do not yet know the best combination of indoor temperature and humidity for our greatest bodily comfort and efficiency.

We do know, however, as a matter of universal experience that it is uncomfortable to remain in air that is still, or as we say that is "dead." If the air that we exhale remains so near our faces that we re-breathe a considerable portion of it at each succeeding breath a feeling of oppression and discomfort ensues. Air stagnation also forms an atmospheric cloak about our bodies which affects their heat conditions. Mere stirring of air often changes discomfort to comparative comfort; witness the effect of the introduction of fans in the New York subway cars. The benefits of sleeping in a cold room in which the warm exhaled air quickly rises so that the next breath is new air, and the benefits of outdoor sleeping are due in great measure to the motion of the air. No system of venti-

lation can be regarded as satisfactory that does not cause a sufficient circulation of the air.

Another thing that we need to appreciate is that the air which we breathe should be clean. So anxious have we been in the past to make sure that the carbonic acid did not exceed some illogical, arbitrary standard that we have overlooked this most patent and obvious need. Of course, the extremes of this quality of cleanliness have been recognized. We know that people who work at dusty trades, in dust laden air sicken and die of diseases that gain a foothold in the lungs; and we send our sick to the mountains and the seashore and spend our vacations in the relatively clean air of the woods and fields and upon the waters. Cleanliness is the great thing to be desired in air as it is in water. From time immemorial water that is grossly foul has been regarded as dangerous, but it is only within a generation or so that water which is only moderately contaminated has been regarded as dangerous. A clean water supply is now a watchword of our modern cities. If precedent is followed we shall come to regard as undesirable much of the air that would not by present day standards be called unclean, as well as air that is grossly laden with dust and foul gases.

Modern cities are dust producers. Streets and pavements and even sidewalks are worn by friction of the traffic, especially in this age of the railroad and automobile; car wheels are ground to metallic dust; fabrics turn to lint; fuel burns with products of smoke and ashes. Dust is being continually produced both within and without our factories and houses.

Recent studies made by us in several cities have shown that the number of dust particles in the air just above the sidewalk is very large, even on quiet days. At the air inlets of some of the commercial buildings in Boston the numbers of particles, as determined by microscopical counts, ranged from 100,000 to nearly 1,000,000 per cubic foot of air. With active wind movement the numbers are probably much higher, but even with the lesser number mentioned the number of particles inhaled by a person in an hour would be a million and a half. To be sure the particles making up this vast number are very tiny, ranging from 0.5 to 15 microns in diameter, with an average of about 3 microns (.003 millimeter), and their combined bulk is not large.

Air contains more dust near the street level than at higher elevations. Tests made on May 13, 1913, at the South Terminal Station, Boston, where air is taken in at the roof, showed lower dust counts than air taken at the street level at various office buildings in the business districts of Boston. Tests made at the John Hancock Building on June 6, 1913, showed that at the street level the air contained 483,000 dust particles per cubic foot, at the fifth story there were 233,000; and at the tenth story, 140,000 per cubic foot. Tests made on July 2, 1913, in New York at

the Metropolitan Life Insurance Building and the Woolworth Building, the last named being the highest building in the world, showed similar reductions in the amount of dust in the air in the upper stories. For example, at the Woolworth Building the air at the street level contained 221,000 dust particles per cubic foot; at the tenth story there were 85,000 at the thirtieth story 70,000, and at the fifty-seventh story 27,000. The dust counts at the Metropolitan Building were somewhat lower than at the Woolworth Building, the number at the street level being 173,000, and at the fiftieth story 21,000 per cubic foot. The lower counts at the Metropolitan Life Building may possibly have been due to the fact that this building is situated near Madison Square and is more isolated than the Woolworth Building which is located downtown in a more crowded section. Both sets of observations were made on warm quiet days.

TABLE I.

TABLE SHOWING THE NUMBER OF DUST PARTICLES PER CUBIC FOOT AT DIFFERENT ELEVATIONS IN VARIOUS WELL-KNOWN HIGH BUILDINGS IN NEW YORK AND BOSTON.

Floor.	Boston, Mass.	New York City.		
	John Hancock Building.	42d Street Building.	Metropolitan Life Building.	Woolworth Building.
	June 5, 1913. 2.50–5.35 P.M.	July 3, 1913. 2.25–4.40 P.M.	July 2, 1913. 2.55–5.15 P.M.	July 2, 1913. 10.10–12.40 A.M.
	Number of Dust Particles per Cubic Foot.			
Sidewalk	483,000	.....	173,000	221,000
2d	306,000	122,000	94,000	163,000
3d	300,000	104,000	71,000	.....
5th	233,000	70,000	51,300	111,000
7th	139,000	49,600	50,000	109,000
10th	140,000	.....	38,000	85,000
11th	.....	37,600	.....	.....
14th	.....	34,000	.....	.....
20th	.....	32,300	36,300	75,000
30th	.....	.....	33,300	70,000
40th	.....	.....	24,000	41,300
50th*	.....	.....	21,000	.....
57th†	.....	.....	.....	27,300

*662 feet high.
†716 feet high.

Winslow has shown that the air of many of the New York schools contains even larger numbers of dust particles than those above mentioned, ranging from 400,000 to 1,000,000 per cubic foot. Studies by the authors at the gymnasium of the International Y. M. C. A. College at Springfield, Mass., have likewise shown that the indoor air contains dust particles in numbers usually more than 100,000 and sometimes even 400,000 per cubic foot. Such results are naturally to be expected, for indoor air is merely the outer air drawn in through the ventilating ducts, the inlets to which are often badly located, while to this outer air is added the dust resulting from friction and air movement of various kinds indoors.

Unclean air contains bacteria and other living organisms as well as lifeless dust particles. The bacteria are usually much less numerous than the dust particles. Our investigations at the John Hancock Building show that at the street level the air contained 1,330 bacteria per cubic foot capable of developing on gelatin at 20° in 96 hours, while at the tenth story the air contained 330 per cubic foot. Speaking broadly it was found that there were from 200 to 300 times as many particles of dust as bacteria. The bacteria capable of growing at the temperature of the human body were still less numerous, there being only 30 such bacteria per cubic foot found at the street level and 17 at the tenth story. The sample from the third story, however, contained 83 per cubic foot, evidently an erratic observation. No attempt was made to determine the particular species of bacteria in these samples, but tests were made for the presence of B. coli and only once was this organism found, namely, in the sample collected at the third story. Molds were also present to the extent of 20 per cubic foot at the street level and 3 at the tenth story.

TABLE II.

TABLE SHOWING THE NUMBER OF BACTERIA AND DUST PARTICLES IN AIR TAKEN AT DIFFERENT ELEVATIONS FROM JOHN HANCOCK BUILDING, BOSTON, MASS., JUNE 5, 1913.

Floor.	Bacteria per Cu. Ft.		B. Coli.	Moulds per Cu. Ft.	Dust Particle per Cu. Ft.
	Gel. at 20°.	Agar at 38°.			
Sidewalk	1,330	30	0	20	483,000
2d	1,200	37	0	13	306,000
3d	417	83	+	8	300,000
5th	720	43	0	15	233,000
7th	310	33	0	10	139,000
10th	330	17	0	3	140,300

Winslow's studies of bacteria in the air of rooms, and especially in the air of sewers and drains, showed a conspicuous absence of pathogenic bacteria. Even in the case of sewer air and drain air the numbers of B. coli found were surprisingly small. Our own results corroborate Winslow's findings. Yet in air, just as in water, B. coli may be regarded as an index of undesirable contamination. In this connection it will be remembered that Doctor Chapin, the well known health officer of Providence, R. I., holds that the danger of transmission of disease by the air conveyance of bacteria is extremely small.

Dust and bacteria do not constitute the only undesirable substances found in unclean air. Chemical examinations of the water from air washers in Boston disclosed the presence of ammonia compounds, nitrites, chlorides, sulphates, free sulphuric acid, and iron. The amounts of these substances varied with the location of the intake ducts. Washers receiving air from the street level showed greater quantities of impurities in the water used for washing than those taking air from a height.

Mention has been made of the dust particles and bacteria in indoor air and of their tendency to outnumber those in outdoor air. The other constituents of indoor air are likewise subject to change. Chief among these are the substances that give rise to odors. Everyone is familiar with the odor of a poorly ventilated room after occupancy by a number of persons. This is due in part to the presence of expired air and to body emanations that accompany physiological processes. The same condition prevails wherever people congregate in restricted quarters, such as halls, churches, theatres, and cars. To some extent the intensity of these disagreeable odors is dependent upon the degree of activity of the occupants: witness the characteristically strong odor of a gymnasium. During the course of the Springfield experiments an increase of the odor of the air after the men began exercising in the gymnasium was very noticeable to one standing in the exhaust air duct.

There is no expression more common than that of "fresh air." Just what is meant by this term? It certainly does not involve the factor of air temperature to any extent, for we use the expression both in winter and in summer, and at times when the outside and indoor temperatures are the same. Neither does it involve humidity. In the opinion of the writers it may be regarded as practically synonymous with clean air in motion, air that is free from dust, from bacteria, and from malodorous or offensive organic emanations and poisonous substances.

Too little attention has been paid in the past to the cleanliness of the air supplied to our buildings. Fresh air inlets are often located with the grossest disregard for the quality of the incoming air. It is not uncommon to see them placed on the sidewalk level, or facing a vacant piece of ground that is swept by clouds of dust, or where smoke or objectionable odors

may be taken in. In one of the buildings of Harvard University the air inlet is placed near a main entrance where automobiles stop and start, and the odor of spent gasoline frequently permeates the building.

The effect of forcing unclean air into buildings is to nullify the result aimed at by ventilation, that is to provide a supply of fresh air. The presence of dust, bacteria and odors not only renders the conditions uncomfortable and deleterious to health but it results in attempts at window ventilation, and this means poor ventilation, unequal heat distribution and draughts.

Supplying buildings with unclean air may often be obviated by a judicious choice of location for the inlet duct. A change of location from near the street to some higher point, or from one side of a building to another may greatly improve the quality of the influent air.

Crowded buildings and dusty city streets will often render it impossible to secure clean air from the outdoor atmosphere, without resorting to artificial purification. Fortunately this purification can be accomplished. Just as unclean water may be made wholesome by the employment of Nature's process of filtration, so can unclean air be purified by the application of another efficient process of Nature, namely air washing. The purifying effect upon atmospheric air of a heavy fall of rain is well known. A shower is said to freshen the air. Not only are suspended particles removed, such as dust and bacteria, but gaseous impurities, such as acid and ammoniacal vapors are dissolved and removed, leaving the air sweet and clean. A determination of dust particles in the air after a heavy rain at Harvard University showed only 25,000 particles per cubic foot, whereas in dusty weather the numbers would have been measured by hundreds of thousands. This figure compares favorably with a determination made over the water of Long Island Sound at a point several miles from the shore, when the air contained 18,000 dust particles per cubic foot.

To ascertain the efficiency of air washing as a means of purification the authors made a study of this method as carried on at several buildings in Boston and Springfield, Mass.

The process of air washing consists of passing the air horizontally through a chamber in which water is falling in drops, as rain, or into which it is sprayed. The sprays are obtained by forcing the water out of perforated pipes or through nozzles placed across the ducts. When the sprays intersect they are said to form a curtain. The object is to bring the air and water into intimate contact. Besides the washing chamber there are heating or tempering coils in the ducts or in a separate chamber, and devices for controlling temperature, a primary object of air washing in the past having been that of conditioning the air with respect to its temperature and humidity. The water used for washing is circulated by means of a pump so that it may be used over and over in the spray chamber

for a considerable time. If desired this water may be cooled so as to influence the temperature of the air. Several forms of air washers are on the market, essentially similar in principle but differing in details of construction.

Although it has been known that air washers tended to clean the air, and they have sometimes been introduced for that very purpose, their efficiency as a means of air purification has not been determined. Accordingly the authors undertook a few preliminary studies in order to get data to serve as a guide in planning a more complete investigation. These studies were made at certain installations in Boston and Springfield, where washers made by different companies are in use and included chemical and bacteriological analysis of the air before and after washing, an analyses of the water before its use and after different periods of use. At Springfield the studies formed a part of a more extensive series of ventilation studies made at the gymnasium of the International Y. M. C. A. College during the winter and spring months.

The washers in Boston referred to by the letters A, B, C, D, and E were supplied with air taken from inlets placed as follows. They were all in the business district.

Washer.	*Position of Inlet.*
A.	Eighth story on the roof.
B.	Above street entrance.
C.	Second story, back side of the building.
D.	Street level, just above sidewalk.
E.	Street level, just above sidewalk.

The analysis of air and water were made by the standard methods of the American Public Health Association supplemented by the use of special apparatus. The results are given in Tables III and IV.

Comparison of the dust counts in the air before and after passing through the water showed that in the case of the five Boston washers the percentage removal ranged from 27 per cent. to 87 per cent. and averaged 54 per cent., while the removal of bacteria ranged from 37 per cent. to 88 per cent. and averaged 64 per cent. Generalizing from the data given in Table III it is fair to say that the air washing process as practised removed about two thirds of the suspended particles,—including dust, bacteria and molds.

The nature of the substances removed by the washers is shown by Table IV. Quantitatively these figures mean little, apart from a knowledge of the volume of water used and the number of times that the same water had passed through the air, and exact data for this could not be obtained. From a comparison of the analyses of the tap water before use

with the washer water after use it is evident that many substances were removed from the air besides dust and bacteria.

When street air was passed through a washer it required but a few hours for the water used to resemble sewage in appearance and analysis. A comparison of the analyses of washers B, D, and E, with those of C and A given in Table V shows how much greater was the amount of dust

TABLE III.

TABLE SHOWING REMOVAL OF BACTERIA AND DUST PARTICLES FROM AIR BY VARIOUS AIR WASHERS, BOSTON, MASS.

Source of Sample of Air.	Date 1913.	Bacteria per Cu. Ft.				Moulds per Cu. Ft. (Gelatine.)	Dust Particles per Cu. Ft.	
		Gelatine at 20°.		Litmus Agar at 38°.				
		Number.	Per Cent. Remov'l.	Number.	Per Cent. Remov'l.		Number.	Per Cent. Remov'l.
Washer A								
Outside . .	Feb. 3	10		0		10	229,600	
Washed . .	"	5	50%	0	.....	0	30,500	87%
Outside . .	Feb. 10	110		0		8	111,100	
Washed . .	"	13	88%	0	.....	3	58,000	48%
Outside . .	May 13	1,000		7		20	178,300	
Washed . .	"	300	66%	7	0%	7	124,700	30%
Washer B								
Outside . .	Feb. 10	27		17		10	158,300	
Washed . .	"	17	37%	7	55%	3	71,300	55%
Washer C								
Outside . .	Mch. 13	13		3		0	248,000	
Washed . .	"	3	77%	0	100%	0	72,000	71%
Washer D								
Outside . .	Mch. 13	57		3		13	241,000	
Washed . .	"	7	88%	3	0%	3	104,000	57%
Washer E								
Outside . .	May 1	187		20		20	729,300	
Washed . .	"	110	41%	7	65%	13	531,000	27%

removed from air near the street level than at higher elevations. The intake ducts of these washers were at the street level, the second story, and the eighth story respectively.

The presence of sulphurous acids in the air of the business districts of Boston was responsible for an interesting phenomenon. These acids resulted from the formation of sulphurous gases during the combustion of coal and, being soluble, were removed from the air and dissolved by

TABLE IV.

TABLE SHOWING ANALYSIS OF TAP WATER BEFORE USE, AND OF WATER FROM VARIOUS AIR WASHERS IN BOSTON, MASS., AFTER USE.

	Before Use.		After Use.						
	Tap Water.		Washer A.			Washer B.	Washer C.	Washer D.	Washer E.
	1	2	1	2	3				
Date of collection, 1913	Feb. 1	Mch. 13	Feb. 3	Feb. 10	May 13	Feb. 10	Mch. 13	Mch. 13	May 1
Number of hours water had been circulated	.....	.....	192	360	48	75	24	34	9
Temperature F°	.....	.....	45°	34°	52°	50°	50°	63°	59°
Turbidity	0	1	3	16	6	35	35	145	28
Color	10	16	15	20	15	17	10	20	39
Odor	2v	1v	3v	3a	3a	3a	2v	3a	3d
Total residue	34.0	40.0	55.0	10.70	96.0	560.0	238.0	765.0	160.0
Loss on ignition	16.0	17.0	13.0	27.0	21.0	151.0	78.0	240.0	46.0
Fixed residue	18.0	23.0	42.0	80.0	75.0	409.0	160.0	525.0	114.0
Kjedahl nitrogen	.190	.168	.228	.580	.220	2.780	.510	1.740	2.650
Albuminoid nitrogen	.068	.084	.084	.132	.106	.332	.136	.850	.425
Free ammonia	.002	.018	.148	.144	.042	1.512	.280	2.350	2.330
Nitrites	.000	.001	.011	.011	.006	.056	.010	.024	.060
Nitrates	.10	.18	.09	.05	.05	2.50	.15	.14	.18
Oxygen consumed	2.5	3.4	3.5	5.5	4.1	10.0	6.2	26.4	8.2
Chlorine	5.0	5.0	5.0	5.2	5.0	16.0	7.0	19.0	10.0
Total hardness	11.0	14.5	20.0	28.5	30.0	307.5	130.0	357.5	45.5
Alkalinity	6.0	7.0	0.0	0.5	0.5	—1.5	—4.5	0.0	—0.5
Incrustants	5.0	7.5	20.0	28.0	29.5	309.0	134.5	357.5	50.0
Iron	0.5	0.2	0.4	1.4	0.7	10.0	7.5	32.0	3.5
Copper	.....	.....	+*	+	0	+	+	+	0
Total Bacteria (Numbers per c.c.)									
Gelatine 4 days at 20° C	25	50	25	15	1,200	60	0	0	8,700
Litmus agar 2 days at 38° C	7	..	2	1	3	10	0	0	12
Moulds per c.c. (Gelatine)	5	..	3	5	..	10	..	..	30

* + signifies that copper was present. 0 signifies that copper was absent.

the water in the air washing process. As long as the water contained alkalinity the sulphuric acid was neutralized, but after a certain length of time an excess of acid was present. This condition was found in several washers. Where it occurred in a washer constructed largely of copper the acid dissolved this metal and formed copper sulphate. As a result there was established a sort of automatic process of disinfection, and the numbers of bacteria found in the washer water were very low.

The gymnaisum of the International Y. M. C. A. College at Springfield afforded an opportunity of studying a new phase of the problem of air washing, namely that of purifying air that had passed through an occupied room. It was supplied with air from a ventilating plant provided with an air washer operated at such a rate that the air in the room was changed every nine to twelve minutes. This plant was well adapted for experiment

TABLE V.

AVERAGE ANALYSIS OF WASHER WATERS.

	Water before Use.	Intake at Street Level.	Intake at 2d Story.	Intake at 8th Story.
	(Results Expressed in Parts per Million.)			
Turbidity	1	69	35	8
Total residue	37.0	495.0	238.0	86.0
Loss on ignition	17.0	148.0	78.0	20.0
Kjedahl nitrogen	0.179	2.390	0.510	0.343
Free ammonia	0.010	2.064	0.280	0.111
Oxygen consumed	3.0	14.9	6.2	4.4
Iron	.35	15.2	7.5	8.0

for the reason that air could be taken in from the outside and washed, or the exhaust air from the room could be returned through the washer and again forced into the gymnasium. Comparison could thus be made between the use of outside air and of rewashed air. As in the Boston experiments analyses were made of the air before and after washing and of the water after different periods of service. Frequent tests were made under different conditions of operation. The results appear in Tables VI to X.

When the exhaust air left the gymnasium it had a noticeably sour and musty odor. After passing through the washer this was almost completely removed and the returned air was fresh and sweet. At the same time the "gymnasium odor" was acquired by the washer water and could be easily detected in the sample bottles. The washer water was also found to contain large numbers of bacteria and many epithelial scales derived from the skin of the men exercising on the floor. Dust, bacteria,

TABLE VI.

RESULTS OF A SERIES OF ANALYSIS UPON WATER FROM AIR WASHER, USING RECIRCULATION OF AIR AND WATER.

Determination.	Tap Water.		Washer Water.				
	1.	2.	3.*	4.	5.	6.	7.
	Jan. 13.	Jan. 15.	12 hrs. Jan. 13.	20 hrs. Jan. 15.	29 hrs. Jan. 20.	31 hrs. Jan. 20.	57 hrs. Jan. 29.
	(Results Expressed in Parts per Million.)						
Temperature	....	43°	52°	56°	51°	54°	54°
Turbidity	0	0	6	10	11	11	15
Color	17	15	37	43	70	73	65
Odor	1v	1v	2a	3a	3a	3a	4s, 4m †
Total solids	35.0	36.0	48.0	67.0	84.0	95.0	106.0
Loss on ignition	8.0	8.0	16.0	25.0	18.0	22.0	22.0
Fixed solids	27.0	28.0	32.0	42.0	66.0	73.0	84.0
Total organic nitrogen	.032	.046	.220	.....	.250	.300	.420
Albuminoid nitrogen	.058	.044	.110	.150	.174	.164	.244
Free ammonia	.004	.002	.954	1.304	1.574	1.608	2.228
Nitrites	.000	.000	.040	.055	.155	.145	.144
Nitrates	.05	.05	.07	.09	.11	.12	.15
Oxygen consumed (5 mins.)	2.6	2.8	4.2	4.5	5.2	5.5	5.9
Chlorine	2.5	2.5	2.7	2.8	3.5	3.5	3.5
Hardness	8.0	6.5	19.5	22.0	30.0	32.5	36.5
Alkalinity	3.5	2.0	14.5	17.5	21.0	22.5	30.5
Incrustants	4.5	4.5	5.0	4.5	9.0	10.0	6.5
Iron	0.15	0.15	1.0	2.2	3.6	4.0	4.4
Free CO_2	3.0	3.0	3.0	3.7	3.5	4.0	4.0
Total Bacteria							
Gelatine, 4 days at 20°	35	44	37,500	85,000	131,000	155,000	180,000
Litmus agar, 2 days at 38°	...	...	....	....	50	50	12
Amorphous matter (Standard units per c.c.)	0	0	730	684	156	246	1,044
Epithelial scales (Number per c.c.)	0	0	14	24	32	32	40

*The first twelve hours were in the nature of a blank run without occupants in the gymnasiums.
†Odor was sour and musty.

molds, nitrogen, and iron were removed from the indoor air by the washer at Springfield to about the same extent as by the washers tested in Boston. The results indicated that under the conditions there existing the exhaust air could be washed and returned to the gymnasium with entire safety and comfort to the occupants of the room and with no apparent sacrifice of wholesome properties. The carbonic acid was not reduced by the air washer,—and theoretically it ought not to be reduced,—but this fact did not at all affect the acceptability of the washed air to the occupants. The details of these experiments are described in *The American Physical Education Review*, October, 1913. Generalizing from these results, it may be said that the recirculated air after washing was cleaner than unwashed outdoor air but was slightly less clean than the outdoor air after washing.

TABLE VII.

COMPARATIVE NUMBERS OF BACTERIA UPON EXPOSED PLATES, USING RECIRCULATION OF AIR AND WATER.

Sample.	Date.	Number Minutes Exposed.	Total Bacteria upon Plate.				Moulds per Plate.
			Gelatine at 20°.		Litmus Agar at 38°.		
			Number.	Per Cent. Removal.	Number.	Per Cent. Removal.	Gelatine.
Using Recirculation	1912						
Exhaust air	12/12	45 sec.	130		18		22
Washed "	"	"	12	91%	2	89%	4
Exhaust "	1/13	2 min.	62		..		15
Washed "	"	"	7	89%	..	....	2
Exhaust " 3 P. M.	1/20	1 min.	170		..		25
Washed " "	"	"	39	77%	..	....	6
Exhaust " 4 "	"	"	52		21		18
Washed " "	"	"	36	31%	8	62%	6
Exhaust " 3 "	1/29	1 min.	55		49		12
Washed " "	"	"	36	35%	3	39%	11
Exhaust " 4 "	"	"	46		60		7
Washed " "	"	"	30	35%	8	87%	2

The advantage of washing and recirculating the air lies in the great saving of heat in cold weather. Mr. D. D. Kimball, who designed the ventilating plant at Springfield, estimated that when the outdoor temperature was 32° F. the saving in cost of operation effected by recirculating washed air was 40 per cent., while with an outdoor temperature of 0°F., the saving was 50 per cent. The use of less coal at Springfield when the

air was being recirculated instead of being drawn in from outdoors was plainly evident and was commented upon by the engineer in charge of the Springfield plant. In the summer the washer may be operated as a

TABLE VIII.

RESULTS OF ANALYSES OF WATER FROM AIR WASHER AFTER SHORT TIME TESTS, USING OUTSIDE AIR AND RECIRCULATED AIR.

Determination.	1. Tap Water.	2. *Washer* Using Outside Air.	3. *Washer* Before Using Air.	4. *Washer* Recirculation Without Occupants.	5. *Washer* Recirculation With Occupants.	6. *Washer* Recirculation Without Occupants
	(Results Expressed in Parts per Million.)					
Date of test	Mar. 4	Mar. 4	Mar. 17	Mar. 17	Mar. 17	Mar. 18
Period of test	.....	6 hrs.	.....	4 hrs.	4 hrs.*	4 hrs.
Time of sampling	1 P.M.	3.30 P.M.	9 A.M.	1 P.M.	6 P.M.	1 P.M.
Temperature	.....	38° F	.....	54° F.	50° F.	55° F.
Turbidity	0	10	1	5	5	5
Color	13	42	15	26	21	24
Odor	1v	1v	2v	3a	3a	3a
Total solids	30.0	66.0	36.0	49.0	46.0	51.0
Loss on Ignition	10.0	32.0	17.0	20.0	17.0	18.0
Fixed solids	20.0	44.0	19.0	29.0	29.0	33.0
Total organic nitrogen	.100	.300	.100	.136	.108	.144
Albuminoid nitrogen	.048	.140	.068	.108	.092	.114
Free ammonia	.018	.218	.006	.404	.362	.508
Nitrites	.000	.016	.001	.007	.005	.007
Nitrates	.05	.06	trace	.06	.06	.06
Oxygen consumed	2.7	4.3	2.6	3.5	3.3	4.0
Chlorine	1.7	1.9	1.3	1.5	1.7	2.55
Hardness	11.0	19.5	10.0	19.5	17.5	20.0
Alkalinity	6.5	12.0	6.5	11.5	10.0	13.5
Incrustants	4.5	7.5	3.5	8.0	7.5	6.5
Iron	0.2	2.5	0.4	0.8	0.7	0.8
Total Bacteria						
Gelatine 4 days at 20°	80	90,000	380	12,000	20,000	2,900
Litmus Agar 2 days at 38°	7	9	3	10	75	55
Moulds on Gelatine	0	200	6	800	300	200
Amorphous Matter	0	1,000	184	638	574	238

*The number of men hours for this period was 180.

cooling plant to keep down the temperature of the indoor air,—or with the windows open it may be shut down to save expense.

The common standard of 30 cubic feet of air per capita per minute, which is now generally applied to school houses, was based upon the idea of keeping the carbonic acid down to a fixed amount. When it became recognized a few years ago that carbonic acid was a negligible factor,

TABLE IX.

QUANTITATIVE DETERMINATIONS OF BACTERIA IN AIR.

Sample.	1. Date. 1913.	2. Bacteria per Cu. Ft. Gelatine at 20°. Number.	3. Bacteria per Cu. Ft. Gelatine at 20°. Per cent. Removal.	4. Bacteria per Cu. Ft. Litmus Agar at 38°. Number.	5. Bacteria per Cu. Ft. Litmus Agar at 38°. Per cent. Removal.	6. Moulds per Cu. Ft. (Gelatine).
Using Outside Air:						
Outside air 1.30 P.M.	Mch. 4	27		7		0
Washed air 2.00 P.M.	"	7	74%	3	57%	0
Exhaust air 1.10 P.M.	"	27		17		3
Exhaust air 3.45 P.M.	"	37		23		16
Outside air 2.10 P.M.	Mch. 11	17		3		0
Washed air 2.40 P.M.	"	12	29%	0	100%	0
Exhaust air 1.30 P.M.	"	57		13		23
Exhaust air 4.00 P.M. (Without Washing.)	"	130		30		30
Outside air 4.00 P.M.	Mch. 18	23		6		23
Exhaust air 4.30 P.M.	"	300		153		40
Recirculation, with occupants:						
Exhaust air 2.30 P.M.	Feb. 13	193		3		20
Washed air 2.30 P.M.	"	44	77%	0	100%	17
Exhaust air 4.15 P.M.	"	100		0		13
Washed air 4.15 P.M.	"	10	90%	0	.....	10
Exhaust air 2.15 P.M.	Mch. 17	483*		56		83
Exhaust air 5.15 P.M.	"	93		26		23
Washed air 5.30 P.M.		66	29%	17	35%	17
Recirculation, without occupants:						
Exhaust air 10.55 A.M.	Mch. 17	170		3		56
Exhaust air 1.05 P.M.	"	83		7		53
Washed air 1.25 P.M.	"	63	24%	7	0%	20
Exhaust air 12.00 P.M.	Mch. 18	86		17		46
Washed air 12.35 P.M.	"	60	30%	3	82%	17

*Possibly influenced by taking sample too soon after starting fans.

some made the inference that a smaller volume of air would suffice. They failed to consider that circulation of the air is of itself one of the essential elements of indoor comfort and a necessary feature of good ventilation.

The cost of heating large volumes of cold air has naturally stood in the

TABLE X.

QUANTITATIVE DETERMINATION OF DUST.

Sample.	Date, 1913.	Number Dust Particles Per Cu. Ft.	Per cent. Removal.	Remarks.
Using Outside Air:				Mild. Thawing.
Outside air 1.30 P.M.	Mch. 4	103,000		Light breeze.
Washed air 2.00 P.M.	"	98,300	5%	
Exhaust air 1.10 P.M.	"	56,300		
Exhaust air 3.45 P.M.	"	115,000		
Outside air 2.10 P.M.	Mch. 11	17,200		Cloudy. Light
Washed air 2.40 P.M.	"	13,000	24.5%	breeze. Heavy rainfall
Exhaust air 1.30 P.M.	"	63,000		previous night.
Exhaust air 4.00 P.M.	"	87,700		
(Without Washing.)				
Outside air 4.10 P.M.	Mch. 18	124,000		Slightly above freez-
Exhaust air 4.45 P.M.	"	200,000		ing. Brisk S. W. winds. Washer idle.
Recirculation, with occupants:				
Exhaust air 2.30 P.M.	Feb. 13	415,000		Temperature below
Washed air 2.30 P.M.	"	149,000	64%	freezing. Light to brisk
Exhaust air 4.15 P.M.	"	266,000		wind.
Washed air 4.15 P.M.	"	122,000	54%	
Exhaust air 5.10 P.M.	Mch. 17	171,000		Temperature about
Washed air 5.40 P.M.	"	91,300	47%	freezing. Light to brisk W. wind. Fair.
Recirculation, without occupants:				
Exhaust air 10.45 A.M.	Mch. 17	131,000		Temperature about
Exhaust air 1.10 P.M.	"	97,000		freezing. Light to
Washed air 1.20 P.M.	"	59,700	39%	brisk W. wind. Fair.
Exhaust air 12.10 P.M.	Mch. 18	90,000		Slightly above freez-
Washed air 12.25 P.M.	"	57,000	37%	ing. Fresh to brisk S. W. wind.

way of efficient ventilation of schools and factories during the cold weather. Another difficulty has been the low indoor relative humidity produced by heating outdoor winter air to a comfortable room temperature. If, therefore, both of these objections can be overcome by washing air

and using it over and over, so as to furnish an ample supply of clean air in motion the method is one that has much to commend it. Naturally there would be a limit to the continued use of the same air, but ordinary leakage and the possible use of a small percentage of outside air would prevent the concentration of any substances not removed by the washer.

Our study of the subject of air washing has led us to believe that it is one of the vital elements of ventilation in localities where it is difficult to obtain a supply of clean air, and that the recirculation of air thus washed is deserving of serious consideration from the standpoint of economy. It is very evident that the air washers now in operation are not giving as high a degree of efficiency as might be obtained with better designs and more skillful operation and the details of the process should be submitted to careful scientific research.

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THE SOCIAL HYGIENE MOVEMENT.

There was recently held in Buffalo, the Fourth International Congress on School Hygiene, concerning which a prominent life insurance expert made the comment—"They called it a congress on school hygiene, but it was in reality a conference on sex education; there wasn't a section of the congress that at some point in its program did not jump the track to discuss certain phases of the sex problem." This was literally true. One of the largest audiences of the entire congress, numbering several thousand persons, assembled to hear President Eliot and the other speakers on the program of the annual meeting of the American Federation for Sex Hygiene.

That the public is now thoroughly interested in the sex problem in all its various phases is certain. The many lectures and social hygiene meetings being held in every section of the United States are evidences of this; the columns of newspaper space devoted to the white slave traffic indicate it; the good, indifferent and vicious plays upon the subject that are bidding for public attention, prove that this interest extends to all classes;

the increasing volume of literature, also good, indifferent, and vicious, shows that the people generally are taking time to read; the fight for legislation relating to marriage, prostitution, minimum wage, protection of girls, is proof that the best elements of society recognize the importance of the problem, and are combining to work out a solution. It behooves the various organizations and individuals interested in the progress of this movement to study it intensively and to plan for the crystalization of public sentiment in sound laws and wise administration.

During the sessions of the International Congress referred to, there occurred another meeting which promises to have a far reaching influence on the situation. This was a joint conference between representatives of the American Federation for Sex Hygiene and the American Vigilance Association. As a result, formal action was taken ratifying a merger and reorganization of the work of these two associations under a single board of directors. A new name is to be chosen later, but the purpose of the union is to build up the strong, practical and representative organization for promoting investigation and progress along all lines of work related to the proper understanding and utilization of sex as an influence in the development of the human race, and for combating venereal disease, commercialized vice and other harmful influences which have developed about the sex functions. There seems to be money enough available to insure the carrying out of any plans adopted. The announcement of the directorate and executives which may be chosen will be awaited with the greatest interest and it is devoutly to be hoped that the personnel will be such as to give assurance of sane guidance in this new agency for human conservation.

The leaders of the new federation have a most difficult task before them. It will be necessary to weld together a large number of diversified and, even, antagonistic elements.

For example, there are those who believe that the teaching of sex hygiene is the only method of practical value; but within the ranks of this group, a difference of opinion exists as to what shall be taught, at what ages the teaching shall be undertaken, and by whom it shall be done.

There are others who believe that moral education of young people constitutes the only safe method of attacking this problem; of these some advocate the influence of the church in developing religious experience, and would suppress all information concerning sex; some would teach the simple facts of sex, and advocate a single standard of morals, encourage early marriage and the promotion of temperance, as the important things to do.

Still others believe the transmission of venereal diseases to be the only important phase of the problem, and advocate strict administrative control of these diseases as the key to the situation. But even the supporters

of this view are sharply divided as to the proper methods to be adopted—Shall we segregate or not segregate the prostitutes? Shall we subject all prostitutes so far as possible to medical examination? Shall we provide isolation wards for venereal cases? Shall we establish venereal disease clinics, as tuberculosis clinics have been established? Shall we approve the prophylactic methods adopted by armies and navies?

Some are interested in this movement as a factor in the great vague field of eugenics.

There are also many equally sincere persons who regard all these efforts as futile. They hold that sex education only arouses in young men and women a morbid curiosity which had better be left dormant, or they say that prostitution has always existed and always will exist, and that the parents of each child can alone deal properly with the matter. To bring together these earnest persons holding divergent views, and sometimes fanatical in their convictions, in support of a scientific, and effective campaign is the most difficult task any public welfare organization has yet set itself.

The spirit of sarcasm evidenced in the article in the July number of this Journal and the bitterness of the reply published in September have been exhibited in a lesser degree many times during the recent history of the social hygiene movement, but there are signs that the future promises better things. One of the sanest, most encouraging pieces of actual constructive work that has been done in sex education is outlined in the second annual report of the Oregon Social Hygiene Society. The establishment of the Bureau of Social Hygiene for scientific laboratory, clinical and field research upon the underlying causes of prostitution and commercialized vice, marks another advance. The inauguration in New York City of a chain of diagnostic stations by the health department, and the making of syphilis and gonococcus infections reportable, is a most important event in the progress of the medical attack. The decision of this same city to add a "venereal" building to its infectious disease hospital group is a still further advance in the right direction.

When we consider a simple list of the serious and carefully planned efforts which are now being made by the various agencies to grapple with the large questions covered by the term social hygiene, it is manifest that the battle is on. The need of the hour is for a strong national organization equipped and manned to direct the fight. The work of the pioneer societies has prepared the way. Their foundation should now be built upon rapidly. There is need for standardizing the pamphlets and other literature which are being distributed. The material for popular lectures should be most carefully reviewed and censored. Exhibits and, particularly, statistics on this subject require to be worked over so thoroughly that their accuracy and import can not be challenged. It is to be hoped that the association

may become an authoritative but conservative bureau of information upon every subject related to the problems of sex.

At the present moment there are two important issues connected with the social hygiene movement, upon which the general American public is seeking advice and guidance. (1) Shall we teach sex hygiene in the public schools? (2) Shall we actively try to suppress prostitution?

There are strong arguments against school instruction as it ordinarily would be given, but they are opposed on the ground that there is practically no such thing as ignorance of sex even among children. The question of sex-education of children is not one of innocence vs. sex knowledge, but of pick-up street tradition vs. the truth about sex. A number of careful educational experiments on this question are now being conducted in various parts of the world, and there seems to be reason for believing that it will be answered in due time. Meanwhile there is no discouragement in the fact that progress is slow in this direction, provided only it be progress. It is vitally important that education on this subject be sound, scientific, and wise. The new association should follow these experiments closely and make its observations available to the interested public.

Similarly it should watch the experiments in the suppression of prostitution and the control of venereal diseases. In theory this is a simpler problem than the selection of what shall be taught about sex, but in practice it is found to possess so many moral, medical, and other angles that the situation seems hopeless to all except the most courageous and persistent workers. Vice Commissions have repeatedly reported the failure of segregation as an effective measure for reducing either the prevalence of prostitution or of diseases associated with it, yet there continues in every city a large body of people who believe that an "unofficial" segregation is the necessary price of freedom from most undesirable scattering of prostitutes throughout residence districts. The experience of other cities is drawn upon for alleged facts and figures to support this position. The new association should be in possession of accurate and complete data about each city or community wherein any activity along these lines has been shown.

In short, the first function of the new society would seem to be the securing of trust-worthy information upon which a constructive program can be based. With the facts in hand a simple and effective educational campaign can be inaugurated, to be followed by the furthering of well considered legislation and the establishment of sound administrative methods. If, in pursuit of such experimental work as may be necessary to provide the desired facts, the hysteria and lack of balance which has too often characterized earlier interest in this problem can be suppressed, the new society will not only have justified its existence but will have earned the gratitude of all those to whom the public welfare is of deep concern. May it prove equal to its task!

SCHOOL VENTILATION IN NEW YORK CITY.

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and
Curator of Public Health, American Museum of Natural History, New York.

Read before the Sanitary Engineering Section, American Public Health Association, Colorado Springs, September, 1913.

Scope and Plan of Work.

As a part of a comprehensive investigation of the educational system of New York City, conducted by a committee of the Board of Estimate and Apportionment, Prof. Charles Baskerville and the writer were asked to make a study of the existing atmospheric conditions in the schools. Our task was to find out, first, whether the air to which the children were exposed during their school hours was satisfactory in quality, and, second, how far any differences observable between different schools were correlated with differences in ventilating plan or operation. The examination of all the six hundred schools in New York was obviously out of the question, but we selected thirty-two typical examples, ranging from modern and well-managed fan-ventilated schools to older buildings in congested tenement districts, ventilated without fans, and including buildings of various sizes from one of the largest high schools to a four-room country school in Richmond Borough. Ten of these schools were studied intensively, being visited once a week between December 2, 1912, and February 14, 1913, while the other twenty-two were visited on one or more occasions between February 14 and March 15, 1913. Each "visit" was made by a squad of three men who spent practically the whole school day in making determinations of temperature and humidity and carbon dioxid in the field and in collecting samples for the enumeration of dust particles and bacteria. Temperature and humidity observations were made with the standard United States Weather Bureau Sling Psychrometer and were supplemented by the use of Tycos thermographs, giving us continuous records for 364 different school days. Carbon dioxid determinations were made with the portable Petterson-Palmquist apparatus modified and improved for our purposes in certain minor details. Microbes in the air were enumerated by filtering a measured volume of air through a sand filter, washing the sand in sterile water and plating on litmus-lactose-agar, the general method recommended by the committee of the Laboratory Section of the American Public Health Association on Standard Methods for the Examination of Air. Dust particles were determined by passing the air through a sugar filter,

dissolving the sugar in a measured amount of water and counting the particles in an aliquot portion under the $\frac{2}{3}$-inch objective, another of the procedures recommended by the committee on Standard Methods. Altogether we made 1,854 observations of temperature and 1,845 of relative humidity with 773 determinations of carbon dioxid, 684 of microbes and 658 of dust particles.

In addition to these routine observations we made a special study of air supply and air circulation in certain selected schools by the use of the anemometer and joss sticks and by an elaborate series of local temperature observations at different points within the rooms; and we had conducted (by Dr. D. R. Lucas) a special investigation of the specific proteid material which Professor Rosenau believes it is possible to detect in air by the use of the anaphylactic reaction.

General Atmospheric Conditions in the New York Schools.

The general results of our routine studies are indicated in Figure I and in Tables I–V below. They are expressed in the form of distribution curves, the abscissæ representing the observed values in each case and the ordinates the percentage of all observations falling within the limits of values indicated below.

Taking the upper graph first it should be noted that although the curve is labelled "Bacteria" it really includes yeasts and molds as well, all microbes in fact, which will form visible colonies on litmus-lactose-agar in five days at room temperature. The most frequent result is twenty-five microbes or less per cubic foot, but the high results pull the general average up to ninety-six. As indicated in Table I, however, 68 per cent. of the samples showed counts of 100 or less and only 9 per cent. counts over 200.

TABLE I.

DISTRIBUTION OF COUNTS OF MICROBES IN AIR OF NEW YORK SCHOOLS.

Microbes Per Cubic Foot.	Under 50.	51–100.	101–150.	151–200.	201–250.	251–300.	Over 300.
Per cent. of samples in each class.....	41	27	17	6	4	2	3

These counts include all sorts of organisms, from all sorts of sources, which are able to withstand drying long enough to be lifted up and blown about in the air. Most of them, of course, are of no sanitary significance; and the values, averaging under 100 per cubic foot and in most samples, much less, must be considered satisfactory by comparison with the results reported by Miquel (150 bacteria per cubic foot in the air of Paris), by

Tenon (40–60 bacteria per cubic foot in quiet hospital air), by Hesse (60 bacteria per cubic foot in a class room before the students arrived, raised to 430 during the hour and 1,000 just after the class had left), and by Soper (140 bacteria per cubic foot at remote end of Fulton Street subway station). In order to obtain an estimate of the bacteria of human origin, which might at times include pathogenic forms, we made all our plates on litmus-lactose-agar as noted above and isolated all red colonies which appeared on the plates. It is well established that acid-forming streptococci are among the most abundant forms in the human mouth while they are absent from sources which have not recently been exposed to human or animal pollution. The numbers of these organisms in school-room air were found by Professor Baskerville and myself in preliminary experiments a year ago to be quite small. We then found among 30,000 colonies isolated from 750 plates, exposed in schools with window ventilation, only ten mouth streptococci.

In the present study, in the examination of a total of 868 cubic feet of air, we found fifty-two mouth streptococci, or six for every 100 cubic feet of air. The average number of mouth streptococci for the individual schools ranged for the most part between two and seven per 100 cubic feet. In one crowded school in a poor district, it rose to fifteen per 100 cubic feet, and in a school in a good semi-suburban district, no streptococci were found in 41 cubic feet of air. The general average of six mouth streptococci per 100 cubic feet gives a ratio of about one of these forms to 1,600 total bacteria.

The trend of epidemiological evidence is strongly against the spread of disease germs by quiet air, as is best illustrated by the practice of some of the most modern hospitals in which various contagious diseases are successfully treated in open wards, with no precaution against air infection, provided only that the spread of disease by direct contact is rigidly excluded. Our bacteriological results seem in harmony with these deductions from practical experience. A child breathes less than 100 cubic feet of air during an average school period and these mouth streptococci must, of course, be far more abundant than pathogenic forms. At a rate of four or five mouth streptococci per day the chance of ingesting pathogenic bacteria from the air is seen to be a very slender one.

The general distribution of dust counts is shown in Table II and in the second graph of Figure I. It will be seen that the largest number of samples showed between 200,000 and 400,000 particles per cubic foot. The general average for all schools was 601,000 particles and 20 per cent. of the samples showed 800,000 or more with a few values ranging up to 2,000,000 and over.

The sanitary significance of these results is probably not great. Dust particles constitute a serious menace to health in industrial establishments,

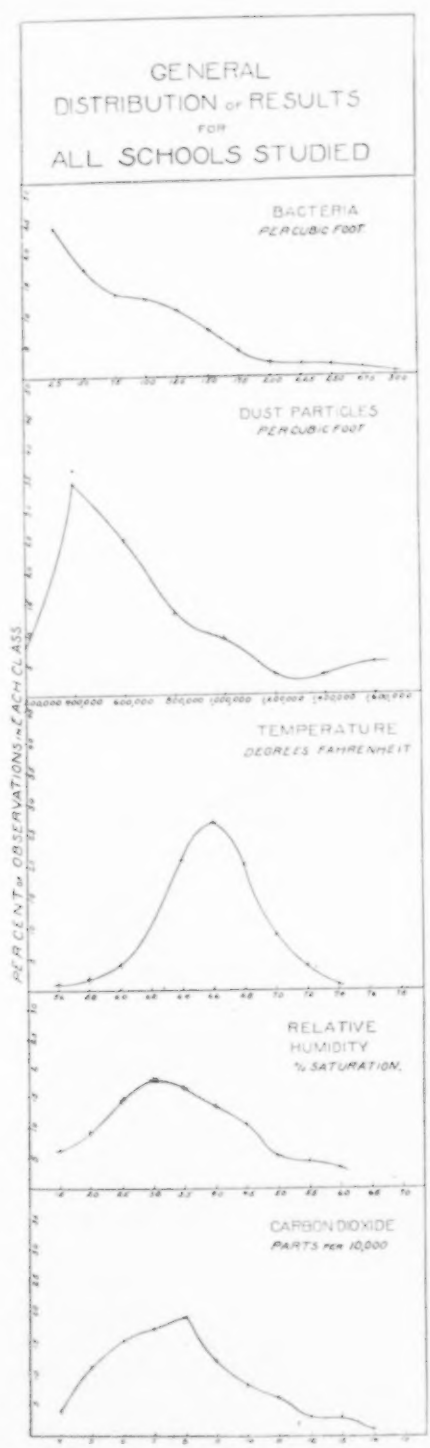

Fig. I.

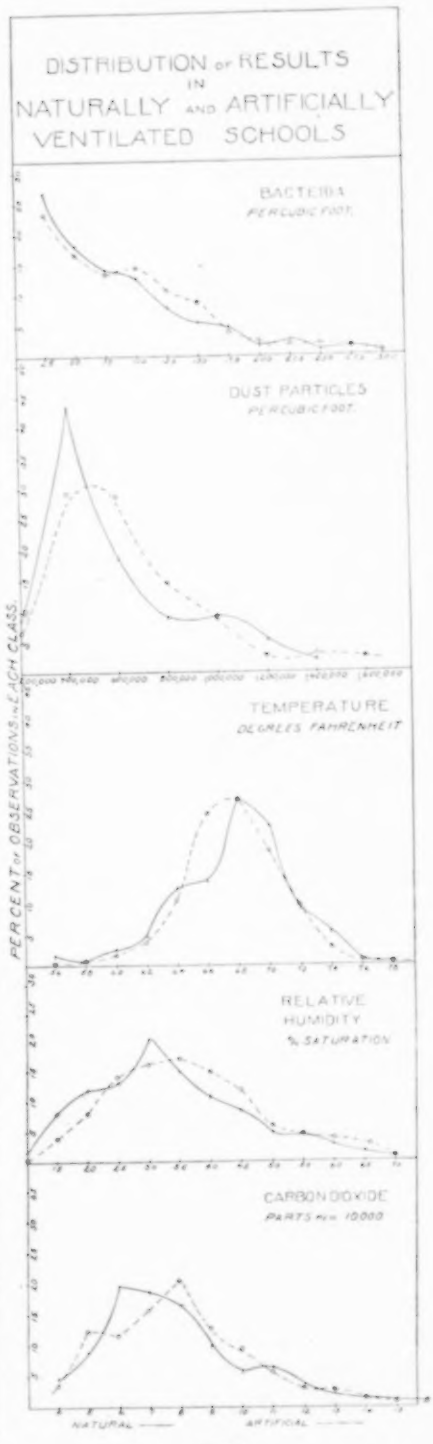

Fig. II.

Fig. I.—General distribution of observations as to the quality of New York schoolroom air.
Fig. II.—Comparison of air conditions in naturally and artificially ventilated schools.

TABLE II.

DISTRIBUTION OF DUST DETERMINATIONS IN AIR IN NEW YORK SCHOOLS.

Dust Particles Per Cubic Foot.	Under 200,000.	200,000 to 400,000.	400,000 to 600,000.	600,000 to 800,000.	800,000 to 1,000,000.	1,200,000 to 1,400,000.	Over 1,400,000.
Per cent. of samples in each class	8	34	25	13	9	3	5

grinding shops, granite cutting sheds and the like, since the hard metallic or mineral particles which are found under such conditions injure the lung tissue and often form a controlling cause in the development of industrial tuberculosis. There is no evidence, however, to show that such particles as occur in ordinary school-room air have any such significance. The particles which we found were for the most part minute and chiefly organic in nature. In the counting cell they separated into two layers, the greater number, floating on the surface, being barely visible under the microscope and consisting in large part of mold spores while less numerous particles settling on the bottom included larger shreds of vegetable fiber and inorganic matter. There is no reason to suppose that particles of such small size and of such nature as were found exert any influence on health.

The general results of the temperature observations made by our field squads with the sling psychrometer are indicated in Table III and plotted in the central curve of Figure I.

TABLE III.

DISTRIBUTION OF TEMPERATURE RECORDS IN NEW YORK SCHOOLS.

Temperature, Degrees F.	Under 60.	60 to 61.	62 to 63.	64 to 65.	66 to 67.	68 to 69.	70 to 71.	72 to 73.	74 to 75.	Over 75.
Per cent. of observations in each class	1	2	4	11	21	27	20	9	4	1

It is evident that these records as a whole indicate very good conditions. The temperature curve centers closely, as it should, about 68°. The table shows only 14 per cent. of all records over 71° and only 5 per cent. over 73°. Sixty-eight per cent. of all records fall between 66° and 71°, a reasonable and equable temperature. On the whole this result must be considered highly creditable and an indication that the children of the

New York schools for the most part enjoy good atmospheric conditions, free from objectionable overheating. An examination of particular schools, however, shows that this general curve covers up markedly different conditions in individual cases; and these will be discussed later, in connection with the question of ventilating systems and their operation.

The general distribution of results in regard to relative humidity are shown in Table IV and in the fourth curve of Figure I.

The range of relative humidity is seen to be a wide one. Sixty per cent. of all observations, however, fall between 20 per cent. and 40 per cent. of saturation and the general average for all schools is 35 per cent. indicating a distinct dry atmosphere.

TABLE IV.

DISTRIBUTION OF RELATIVE HUMIDITY RECORDS IN NEW YORK SCHOOLS.

Relative Humidity, per cent. Saturation.	Under 16.	16 to 20.	21 to 25.	26 to 30.	31 to 35.	36 to 40.	41 to 45.	46 to 50.	51 to 55.	56 to 60.	Over 60
Per cent. observations in each class.....	6	9	14	17	16	13	10	5	4	3	3

The chief controlling factors in the humidity of the school room are of course, the moisture of the outside air and the extent to which the temperature of the air is raised on entering the building. We found a close correlation between outdoor temperature and indoor relative humidity, closer if anything in the naturally ventilated than in the artificially ventilated schools. This is an important point in view of the criticism often leveled at the supposedly abnormal air of fan-ventilated schools. It does not make the least difference whether air is heated in the ducts or in the rooms, the same rise in temperature producing the same drying effect.

The only way to avoid dry air in the school room with certainty is by means of fan ventilation combined with artificial humidification. We studied two examples of this in School 6, Brooklyn (where the air is washed in an air-washer of the spray type) and in School 27 (where half the building has air humidified by a steam jet). Neither school has automatic humidity control. The air in these schools was more moist than the average though not very markedly so. In School 6, 75 per cent. of all observations were under 50 per cent. saturation and 21 per cent. under 35 per cent. saturation, the corresponding proportion of observations falling in these classes being 83 per cent. and 58 per cent. for the humidified half of school 27 and 90 per cent. and 62 per cent. for the average of all schools.

How far we are justified as sanitarians in demanding effective artificial humidification of school-room air seems to me very uncertain. There is a strong and probably correct impression that very dry air in the school room is objectionable but this impression rests on no sound basis of demonstrated facts and there are, so far as I am aware, no physiological experiments which enable us definitely to say that a humidity of 50 per cent. or 25 per cent. of saturation is harmful to health.

Our results in regard to carbon dioxid are summarized in Table V and in the lowest graph of Figure I.

TABLE V.

DISTRIBUTION OF CARBON DIOXID DETERMINATIONS IN AIR OF NEW YORK SCHOOLS.

Carbon Dioxid, Parts per 10,000.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.	17.
Per cent. of observations in each class.....	4	11	15	17	19	12	8	6	3	3	1		2

The general average value for all schools was 8.1 parts per 10,000. Sixty-six per cent. of the observations fell below 8.5 parts which may be considered a very satisfactory result on any standard. Twenty-nine per cent. of the tests showed between 8.5 and 12.5 parts, which would have been considered high on the older standards established when carbon dioxid was held to be a measure of some mysterious poisonous matter in the air. The present tendency among physiologists and sanitarians is to allow a more liberal standard, however, Dr. J. S. Haldane, Dr. Leonard Hill and Dr. M. S. Pembrey in testifying before the English Departmental Committee on Humidity and Ventilation in cotton-weaving sheds favored a standard of 12 parts per 10,000 for factories and I see no reason why a more rigid standard should be enforced in school rooms. There remain 6 per cent. of the tests, however, showing over 12.5 parts, which are clearly excessive. These were associated with overcrowding and deficient air supply in individual rooms. Supplementary observations made in four schools during evening sessions (when there is no artificial ventilation) showed some very high carbon dioxid values ranging in one case with gas burning up to 26.0 parts. This is a special problem which deserves more attention than it receives in many cities.

Studies of Air Supply and Air Circulation.

Our analytical data were supplemented by a study of the distribution of air to individual rooms and its circulation within the rooms themselves

which are of some interest as showing how the mechanics of ventilation work out in practice.

Inlet and outlet velocities were studied with the anemometer in fifty rooms, twenty-five in one of the best fan-ventilated schools (33 Bronx), sixteen in four fan-ventilated schools where high carbon dioxid values had been found, and nine in four schools ventilated without fans. The amount of air supply in the fan-ventilated schools is indicated in Table VI which shows that in School 33 the amount was more than ample while in the poorer school it was inadequate.

TABLE VI.

AIR SUPPLY IN WELL-VENTILATED AND POORLY VENTILATED ROOMS.

Cubic Feet of Air per Pupil per Minute.	Number of Rooms in Each Class.					
	Under 10.	10 to 30.	30 to 50.	50 to 70.	70 to 90.	90 to 110
Well ventilated rooms (School 33)	.....	2	8	9	4	2
Poorly ventilated rooms	2	12	1	1	.....	.....

In School 33 the effective area of the inlets averaged 5.1 square feet and of the outlets 5.6 square feet and the linear velocity at inlets and outlets, respectively, averaged 373 feet and 141 feet. In the sixteen poorly ventilated rooms the average inlet area was 4.4 square feet, the average outlet area 4.0 square feet, the average inlet velocity 189 linear feet and the average outlet velocity 83 linear feet. The average number of pupils per room was thirty-five for School 33 and forty-five for the sixteen poorly ventilated rooms. For the most part we found a good plenum condition in all the fan-ventilated rooms as shown in Table VII. The very high ratios were usually in rooms with doors or windows open.

TABLE VII.

RATIO OF AIR ENTERING AT INLET TO AIR LEAVING AT OUTLET.

Ratio.	Forty-one Fan-Ventilated Rooms.					
	Under 1	1 to 2.	2 to 3.	3 to 4.	4 to 5.	Over 5.
Number of rooms	2	11	10	6	4	8

The results obtained in the naturally ventilated rooms are not very significant since doors and windows were freely opened. It is of interest to note, however, that in one school we found inlet velocities of 200 and 300

linear feet per minute without fans, maintained by enormously high temperatures of inlet air.

The circulation of air within the rooms themselves was studied by the use of smoking joss sticks and by an elaborate series of local temperature measurements. The results obtained by the use of the joss sticks in about seventy rooms were very hard to generalize. In about half of the fan-ventilated rooms there were clean cut currents which could be traced across the upper part of the room, down the side wall opposite and back along the floor to the outlet. In an equal number of cases, however, the currents were indefinite and broken and in a few cases no currents at all could be discerned. In the rooms without fans the currents were usually very erratic, although in one or two cases a definite circulation was produced by windows open at top and bottom. In general the naturally ventilated rooms were much more subject to local drafts than were those ventilated by fans.

The local temperature observations were on the whole more valuable as throwing light on air circulation. In twenty-four rooms in fan-ventilated schools we found an average increase in temperature between inlet an outlet of 4.3° which illustrates the importance of keeping incoming air under 66° if the room temperature is not to rise above 70°. The outlet temperature corresponds very closely to the general room average. The average difference between these two readings for thirty observations (ignoring the direction in which the deviation occurred) was just 1° and only two observations showed differences of over 2°. This indicates that the outgoing air is a pretty fair sample of that in the room and that its temperature may be taken as a fair measure of that of the room as a whole. The difference between bottom (three feet above floor) temperature and top (twelve feet above floor) temperature was inconsiderable, and more variable than might have been expected. Of twenty-six rooms in which both were determined, just half showed a higher temperature at the top than at the bottom, while in the rest, the upper air was cooler. The top excesses were higher than the bottom excesses, however, averaging over 2.0° instead of under 1.0°. The slight extent of the differences observed is probably due to the fact that on the one hand cool air was being blown in at the top of the room while on the other hand the air as it was warmed in the room tended naturally to rise. This condition must interfere to some extent with normal air circulation and offers a certain argument in favor of upward as opposed to the usual downward ventilation. Finally, the range between the maximum and minimum individual temperatures observed in the rooms is significant as a measure of general air circulation. The differences ranged for individual rooms between 3.0° and 15.1°, and averaged 6.2°, showing on the whole a fairly good mixture of the air. These observations were all made in fan-ventilated rooms. In rooms ventilated

without fans conditions were more variable. A marked difference appeared as might be expected, in the relation between top and bottom temperatures. Of the fan-ventilated rooms just as many were cooler near the ceiling as were warmer there, although the average temperature for all the rooms was about 1.0° higher at the top. Among eighteen rooms without fan ventilation (that is without a current of cool air blown in near the top) all but one showed a higher ceiling temperature, the excess in two cases being over 11.0 and averaging 5.5°. Another marked difference between the fan-ventilated and the artificially ventilated rooms lies in the evenness of temperatures at different points. The range of difference between maximum and minimum room temperatures, for the fan-ventilated rooms as noted above, was from 3.0° to 15.1°, and the average 6.2°. For thirty-nine naturally ventilated rooms, it ranged from 1.2° to 20.0° and averaged 7.7°. Obviously the air circulation is rather defective when such conditions exist.

It may be of interest to note that in five of the naturally ventilated rooms, all in one building, the temperature of the incoming air was respectively, 83°, 86°, 90°, 98° and 125°. In the latter case one of our thermometers (registering to 130°) was burst by the heat of the inlet air the first time the temperature was taken.

Comparison between Naturally and Artificially Ventilated Schools.

For the purpose of estimating the value of fan ventilation, as actually operated in New York, curves were plotted for all the schools classified on this basis and this curve is reproduced in Figure II, page 1161. Of course it must be understood that by natural ventilation it is meant simply that fans are not running. In almost all cases, ducts and often heating coils were there and air was undoubtedly passing through them. So, on the other hand, where fans were in operation, windows were often open and outside air passing in or out through them. The distinction is made solely on the fact that fans were or were not in operation in connection with the particular room in which each test was made.

The general results for the two classes of schools are on the whole remarkably alike. The fan-ventilated schools show more dust, more humidity, more carbon dioxid and a somewhat more equable temperature; but none of the differences are very great or very significant.

The high humidity and high carbon dioxid in the fan-ventilated schools can best be accounted for on the assumption that in the window-ventilated schools on the whole, there is actually more air supplied than is blown in by the fans in the other group. The higher dust counts may perhaps be due to the same thing, less air to dilute dust produced within the

school, or to the fact that air entering at a high velocity through a duct brings in more dust from outside than does air coming in more slowly through window openings. In dust and carbon dioxid, the fan-ventilated schools appear slightly inferior to the others. In humidity they are better (if dry air be a disadvantage). In temperature they are also somewhat better, showing less observations over 72°.

So far as temperature is concerned, however, it should be noted that the curve for the fan-ventilated class conceals wide variations between the individual schools included in it. Of our ten regular schools it is noteworthy that the four really good records (from the standpoint of temperature) were in fan-ventilated schools. The three wholly or partly naturally

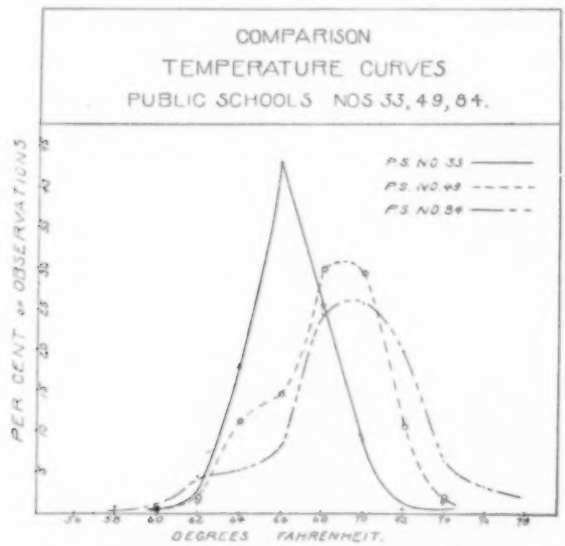

Fig. III.—Temperature curves for a good fan-ventilated school (33), a naturally ventilated school (49) and a badly-operated fan-ventilated school (84).

ventilated schools are mediocre or poor; and two fan-ventilated schools are worst of all. In Figure III are shown typical curves for these three classes. Either almost perfect conditions or very poor conditions may be obtained with fan ventilation according to the care and intelligence of the janitor in charge.

On the whole it can be said that comparing the actual condition of rooms ventilated with and without fans, New York was not last winter deriving any material advantage from its fan ventilation as actually operated.

The Problem of Operation.

This brings us to the crux of the whole matter, as it was made evident in this investigation, the problem of careful operation.

We found certain schools of either the fan-ventilated or the naturally ventilated type which had an ample air supply and uniformly low carbon dioxid values. We found other schools, of both types, in which the supply of air was inadequate and carbon dioxid figures consequently high. In the case of fan-ventliated schools this usually meant low-inlet velocities (sometimes inadequate inlet areas), or overcrowding, while in the naturally ventilated schools it meant either overcrowding or neglect to open windows. It may be noted that the worst carbon dioxid record obtained in any school was in a four-room country school in Richmond Borough, heated by hot air (five records out of eleven over ten parts and three over twelve parts), and the next in a large plenum school on the East Side (twenty-three out of fifty-four records over ten parts and ten over twelve parts). In the latter case the special rooms studied showed an air supply of only 14.2 cubic feet per pupil per minute.

The most striking results of careless operation were shown, however, in the matter of overheating. In the case of the naturally ventilated schools the coöperation of both janitor and teachers is required in order to secure good results and where so many persons are concerned it is practically impossible to reach a maximum of efficiency. As pointed out above, the temperature curves for our naturally ventilated schools were all more or less mediocre. Such a result as that indicated in Figure III for School 33 could scarcely be attained where window ventilation plays any large part.

In fan-ventilated schools on the other hand the whole responsibility rests (or should rest) with the janitor and either very good or very bad results may be attained according to his intelligence and responsibility. The continuous records obtained by our recording thermographs brought out the importance of the operating factor with startling clearness and four of our curves are reproduced herewith to illustrate the variation which occurred.

Figure IV shows the admirable conditions maintained in School 33, to which reference has been made above. It will be noted that for the twenty days our clock was in the school the temperature was maintained with perfect regularity close to 65°, never once in the rooms where the clock was placed rising over 70°. Figure V shows a record almost equally good. Here the janitor allows the building to cool off rapidly after 3 o'clock an economical procedure if not carried to the point of chilling the pupils.

Figure VI shows a striking contrast to the last two figures, giving a clear picture of the exaggerated variations in temperature which occur in a carelessly operated school, provided with fans which are often not in operation. Out of 113 sling-psychrometer records in this school thirty-two or 28 per cent. were over 71° and thirteen or 11 per cent over 73°. The thermograph records are the worst obtained anywhere. On the most spectacular day, January 9, starting in at 63° at 8 o'clock, the temperature

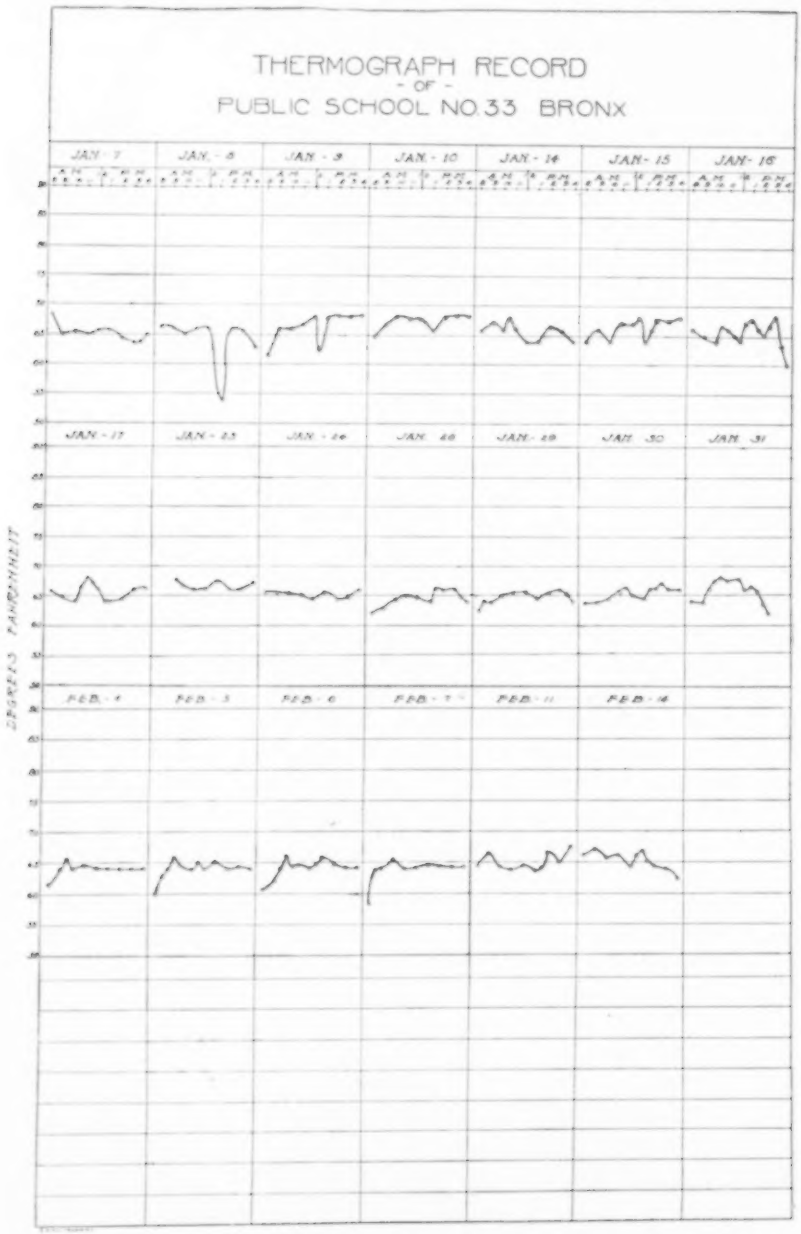

Fig. IV.—Automatic temperature records in a well-operated fan-ventilated school.

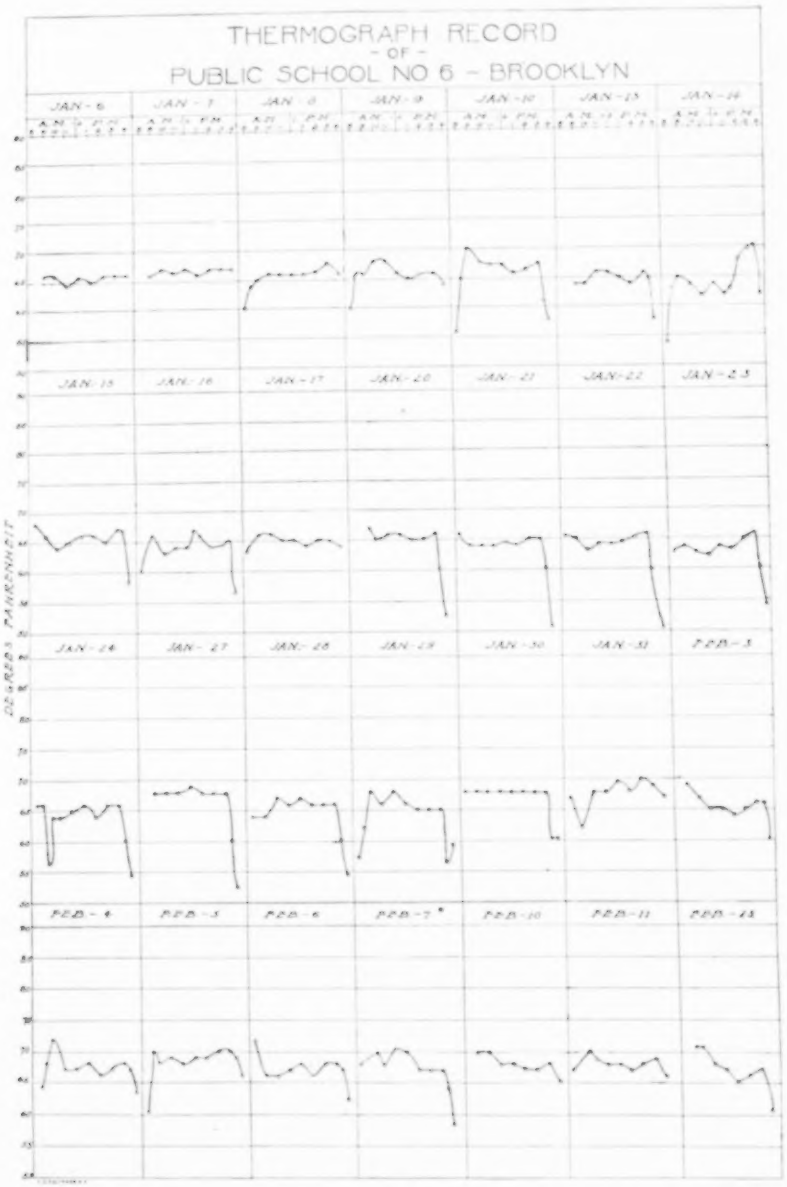

Fig. V.—Automatic temperature records in a well-operated fan-ventilated school.

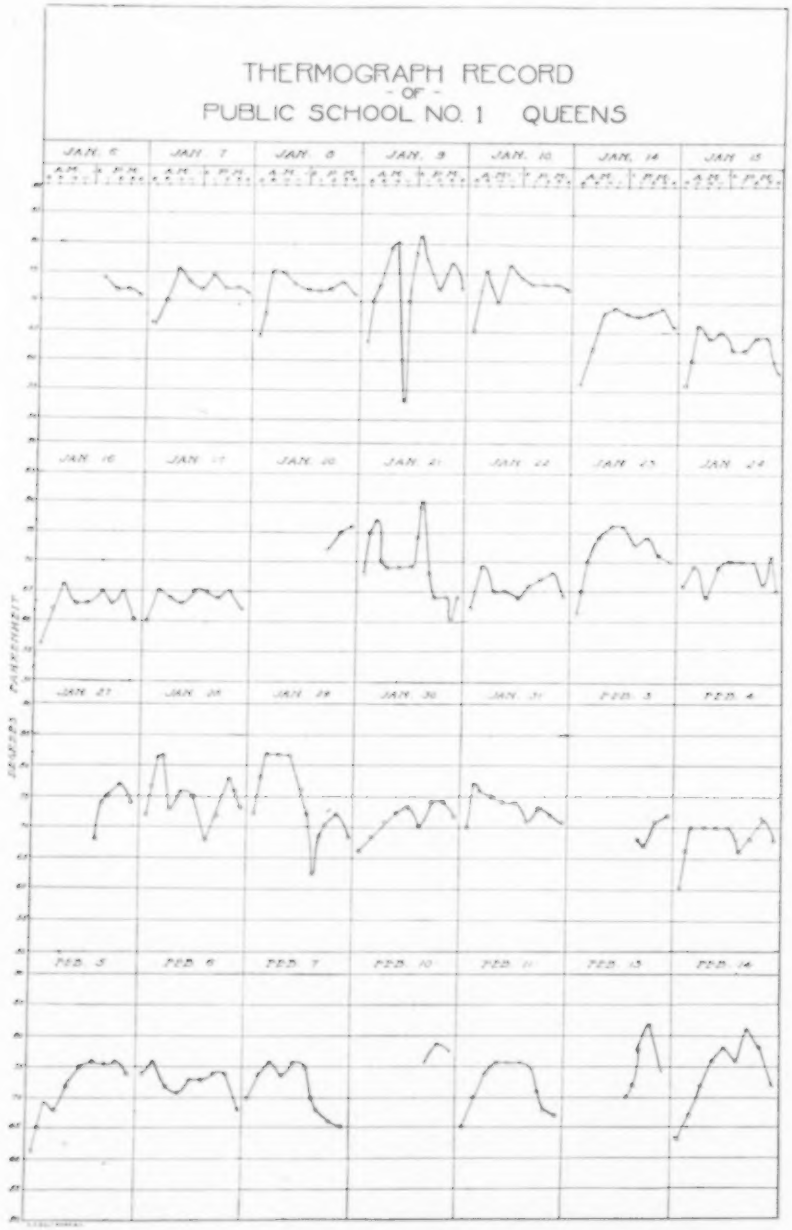

Fig. VI.—Automatic temperature records in a badly-operated fan-ventilated school.

was rushed up to 80° at 10.30. Then in a fit of remorse on the part of the janitor, or a spasm of self-defence on the part of the teacher in the particular room where the clock was placed, the temperature was reduced to 53° at 11.15. The relief was short lived, however, for the thermograph registered 81° at 12.30, and stayed over 72° for the rest of the day. On eighteen out of twenty-eight days for which we have records in this school the temperature reached 75° and on six of them it reached 80°.

Figure VII shows very bad conditions as to over heating in a naturally ventilated school. During the six days for which we have records the temperature was almost constantly between 75° and 80° and once reached 87°.

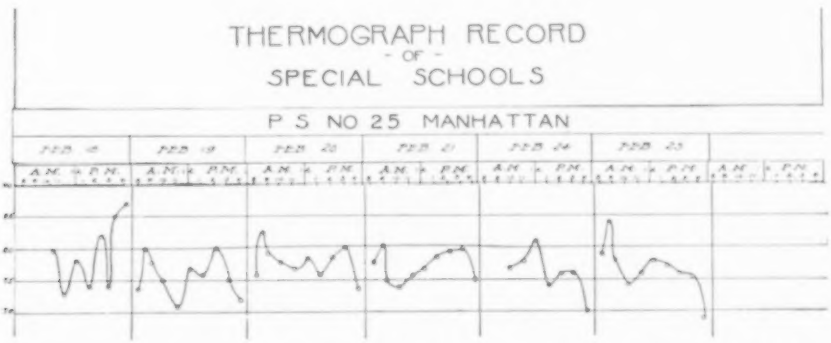

Fig. VII.—Automatic temperature records in a badly-operated naturally-ventilated school.

As a result of this portion of our studies, Professor Baskerville and I concluded that "In certain schools, as strikingly indicated by our thermograph charts, extravagant variations of temperatures with gross overheating are the rule rather than the exception, and the effect upon the health and efficiency of the children must be a serious one. So far as we can discover, these bad conditions are not due primarily to faults of construction in the ventilating systems but to careless operation on the part of the janitors in charge, or to interference with the janitors by teachers." In order to remedy this condition we urged that "a thermograph of some improved type be thus installed in each school building and that the records obtained be carefully inspected and made the basis for an efficient control of ventilating systems and janitorial service," and we recommended that these records be supplemented by periodical studies of temperature and volume of air at the room inlets.

Criteria for School-Room Air.

The chief value of these investigations lies, perhaps, in their possible use as a basis for comparative studies in the schools of other cities, which

are greatly needed if scientific records are to take the place of opinion in the field of school ventilation.

The results obtained in regard to dust and bacteria seem to indicate that, so far as these suspended matters are concerned, the air of the New York schools is in a satisfactory condition, without any special measures of protection such as ozone disinfection or air washing. We have a reasonably good basis for the conclusion that a count in the neighborhood of 100 microbes per cubic foot is entirely normal for city air and the results here reported in regard to the proportion of mouth streptococci found do not lend any weight to the belief that such air can play any part in the transmission of microbic disease. For dust particles comparatively few determinations have been reported by methods at all comparable with ours. Here too, however, there seems no reason to conclude that a dust count of half a million to a million particles (visible under the $\frac{2}{3}$-inch objective) indicates anything more than a normal and innocuous condition. It seems to the writer in view of these results, that the tests for dust and bacteria in school-room air are of relatively minor practical importance except in cases of some special local pollution yielding results considerably in excess of those found in New York.

So far as carbon dioxid is concerned our results indicate that it is comparatively easy, either with or without the use of fans, to keep the air in a school room so changed that its carbon dioxid will average well under ten parts per 10,000 and will rarely exceed twelve parts. This test furnishes an excellent measure of air change and under ordinary conditions such an air change is essential in order to remove odors and preserve a freshness agreeable to the senses. Where air is recirculated, however, with washing or chemical treatment to remove odors, the carbon dioxid standard may have to be relaxed still further, although it will always be of value as an index of what is going on in the way of air dilution.

In view of the claim of Rosenau and Amoss that specific proteid compounds of human origin can be detected in respired air by the delicate physiological reaction of anaphylaxis we devoted considerable attention to this point. Dr. D. R. Lucas, who conducted this part of the investigation, was able easily to demonstrate the presence of such specific proteid substances in the saliva under carefully controlled conditions but was unable to detect them in material condensed from the breath or in air heavily contaminated by the respiration and exhalation of dogs and human beings. We were forced to conclude that "there is at present considerable uncertainty as to the presence of such specific proteid substances in demonstrable amounts in respired air and that there is absolutely no evidence of the presence of any organic substances of a deleterious nature in such air." Similar experiments carried out simultaneously by Dr. Charles Weisman at Columbia University and published as a Doctors' Disserta-

tion have led to the even more definite conclusion that "the results of these experiments disprove the statements of Rosenau and Amoss that the breath contains 'volatile' protein and that such 'volatile' protein is an important respiratory factor."

There seems no good reason to doubt the general soundness of the conclusion arrived at by Flügge eight years ago that "Whenever in closed crowded rooms certain impairment of health ensues, such as headache, dizziness, nausea, etc., these symptoms are to be attributed solely to heat retention." This position may at any time be modified by experiments demonstrating the presence of chemical poisons in respired air but such experiments have not yet been made public and at present it seems clear that overheating is the chief evil to be guarded against in conditioning the air of school rooms.

The one vitally important thing that needs to be done at present in connection with school ventilation is to obtain records of actual school-room temperatures and to remedy the abuses that such records will certainly reveal. If in New York City, where a great deal of public attention has been focused on school ventilation during the last few years, we found over one seventh of our records of temperature over 71° it is probable that schools in many smaller cities and towns would show very much worse results.

Finally the problem of humidity is a most important one but its satisfactory answer must wait for further physiological investigation. The air of all school rooms kept at a temperature between 60° and 70° in winter must necessarily be dry, as we have found it in New York, unless artificial humidification be resorted to. How far such artificial humidification is required, however, cannot as it seems to me be definitely stated without a sound physiological basis which is still lacking.

A STUDY OF THE HYGIENIC CONDITION OF THE AIR IN CERTAIN TEXTILE MILLS WITH REFERENCE TO THE INFLUENCE OF ARTIFICIAL HUMIDIFICATION.

H. W. Clark and Stephen DeM. Gage.

Read before the Sanitary Engineering Section, American Public Health Association, Washington, D. C., 1912.

For many years the subject of occupational hygiene has attracted the attention of sanitarians. Since its creation in 1869, the Massachusetts State Board of Health has made many investigations of the working conditions in different industries, and as a result of these investigations laws have been framed and enacted to protect the health of persons employed in a number of industries. In 1906, the report of an extensive investigation of occupational hygiene in more than sixty different Massachusetts industries was published, in which the conditions in the various departments of the textile industry were treated in detail,* and attention was called to the apparently excessive heat and moisture which the manufacturers considered it necessary to maintain in the air of the rooms where certain processes were employed.

In 1910 a law entitled "An Act Relative to Regulating the Humidity and Temperature of the Atmosphere in Textile Factories" was passed by the Massachusetts legislature,† by which not only was the amount of moisture which might be present in the air restricted to certain specified limits, but it was also provided that only pure water might be used for the introduction of artificial humidity. The enforcement of this law was placed in the hands of the State Board of Health.‡

Although the relation of the humidity of the air to the health of textile employees has received comparatively little attention in this country, it has been under investigation by the English government for over twenty years, and the amount of moisture artificially introduced into weave sheds has been under government control in England since 1889, and rules regulating both temperature and humidity in cotton weave rooms have been in operation since 1898.§ The Massachusetts law followed the English regulations quite closely with reference to the permissible limits of humidity and temperature, but applies those limits to both the spinning and weaving

*Thirty-eighth Annual Report, Mass. State Board of Health, pp. 455–487.

†Chapter 543, Acts of 1910.

‡After June 1, 1913, the enforcement of this and other factory laws becomes vested in a new State Board of Labor and Industries.

§Reports Departmental Committee on Humidity and Ventilation of Weaving Sheds, London, 1909, 1911.

departments of all textile factories, and also provides that only pure water shall be employed for producing artificial humidity in any part of the textile industry.

The provisions of the Massachusetts Act with reference to the permissible limits of humidity were specific, but the choice of instruments to be used for humidity determinations was left entirely to the discretion of the State Board of Health, and while many of the mills were more or less completely equipped with such instruments, there was no uniformity in the type, nor was there any reliable data by which the relative accuarcy of these different instruments could be ascertained. Furthermore, what information was available as to the condition of the air in Massachusetts textile mills was entirely the result of inspection, and little practical information was at hand as to influence of various methods of artificial humidification upon the condition of the air, nor as to the effect of the character of the water which might be used for introducing humidity. During 1910 and 1911 studies were made to ascertain the relative accuracy of various types of instruments used for measuring humidity, and to determine the condition of the air in typical mills where artificial humidification was employed. The results of the comparison of various types of hygrometers, psychrometers, etc., will shortly be published elsewhere, and it is with the studies of the air in the mills which were made by the staff of the Lawrence Experiment Station that the present paper has to deal.

Influence of the Condition of the Air upon Health and Comfort.

While the varying composition of the mixture of gases and impurities called air has been known for many years and the effect of many of the components and impurities upon the human organism has been determined, it is only within a comparatively few years that it has been fully realized how great an influence the condition of the air exerts upon the general health, comfort and energy of individuals and communities. Pure air is a mixture of about four parts nitrogen and one part oxygen. Pure air, however, is practically unknown and the air which surrounds us always contains certain amounts of water vapor, of other gases, and of finely divided particles of organic and mineral matter together with greater or less numbers of living organisms, all of which may effect in one way or another the health or comfort of the individual. The human body is so constituted that it readily adapts itself to considerable fluctuations in the proportion of oxygen and nitrogen of the air, and it has been amply proved that the amounts of carbon dioxide which are at all likely to be present in mill air are without any appreciable affect. Carbon monoxide, which is an active poison, may occasionally be present in the air of mills in which gas is used for fuel or lighting. Gas is still used for lighting in some of the

older mills, and in some cases gas flames are used for singeing the cloth in the finishing process. The probability of carbon monoxide being present in measurable amounts in the air of the larger mills, however, is extremely slight. Other gases such as methane, hydrogen, etc., which because of their explosive properties when mixed with air are of extreme importance in the question of the air in mines, etc., and chemical fumes and vapors which may effect the health of employees in certain industries apparently have no place in the present problem.

The physical condition of the air, however, is a much more important factor, the circulation of the blood, the assimilation of food, and practically every other function of the body being directly or indirectly affected by the temperature and humidity. The body is constantly producing heat which must be expended in energy or in the evaporation of moisture or must be lost by radiation. The performance of the body functions and the health of the individual are completely dependent on the elimination of this body heat. The body will perform its functions for a time even when surrounded by air which is considerably above the body temperature if the humidity is not too great, the excess body heat being eliminated by the evaporation of the profuse perspiration which is usually induced under such conditions. On the other hand, if the temperature of the air be lower than that of the body the excess body heat will be lost by radiation even although the air be saturated with moisture. It the temperature of the air rise above that of the body, however, and the air is saturated with moisture, there is no way for the excess body heat to escape and fever follows with all its accompanying derangements of the body functions. Persons employed indoors, and especially those whose occupations are more or less sedentary are particularly susceptible to the physicial condition of the air. In a cool bracing atmosphere with relatively low humidity all the body functions are more active, breathing is deeper and more frequent, the circulation of the blood is increased, the digestion of food is stimulated, and more and a greater variety of food is consumed, with the result that the various ingredients necessary for the upbuilding of the body cells are not only more numerous but are better assimilated. In a hot moist atmosphere, however, the conditions are reversed, the blood is brought to the surface of the body, and the brain and organs of digestion and absorption are depleted, and not only are mental and physical activity reduced but the general resistance of the body to disease is lowered. The feeling of depression felt in badly ventilated rooms is largely caused, not by excess of carbonic acid or depletion of the air of its oxygen or by toxic substances emanating from the occupants, but from the fact that the temperature and humidity have increased and normal evaporation from the skin has been reduced, thereby affecting the temperature-regulating mechanism of the body, and the entire nervous and circulatory systems. According to

Haldane,* and others, it is the sensible temperature, or that indicated by the wet bulb thermometer, which the body feels, and the actual or dry bulb temperature and the relative humidity are of minor importance under ordinary air conditions. With a wet bulb temperature above 88° F. in still-air heat stroke is likely to occur even with persons wearing little or no clothing and doing no work, while in the case of persons dressed in ordinary clothing and doing muscular work serious effects may follow at very much lower sensible temperatures. On the other hand, eminent physicians assert that excessively dry air is harmful, causing irritation and thickening of the mucous membranes and aggravation of catarrhal conditions. As to what degree of humidity is most conducive to the comfort of indoor workers is an open question, and undoubtedly depends somewhat upon the nature of the employment.† There is little question, however, that the comfort, and probably the health, of persons employed in the majority of textile processes is affected to a greater or less extent as the wet bulb temperature of the air increases above 70 to 75° F.

Ordinary air always contains a greater or less amount of both dead and living matters in suspension which may have an important influence upon the health. The dead matter or dust, consisting of particles of mineral matter from the streets and pavements and from vehicles and machinery, and of dead organic matter from the floors and walls, from clothing and from the emanations of men and animals, especially when present in excessive amounts, irritates the mucous membrane of the lungs and respiratory passages and render them more susceptible to invasion by the germs of disease. The living matter consists of bacteria, yeasts and moulds which are always present in greater or less numbers, and which have found their way into the air attached to dust particles, or have been projected directly into the air from the body by the acts of coughing and sneezing. So far as is known the yeasts and moulds have little pathological significance, but it is well recognized that the germs of tuberculosis, pneumonia, influenza and perhaps other diseases are frequently transmitted through the air.

Respiratory Diseases in Textile Cities.

Studies of the textile industries in foreign countries have led to the belief that persons employed in them are exposed to conditions and influences which would warrant the classification of these industries among those which are detrimental to health. If the health of textile operatives is unfavorably influenced by the nature of their employment or by character-

*Haldane, Report Departmental Committee on Humidity, etc., 1909, Appendix III.

†A detailed discussion of the physiological effects of temperature and humidity will be found in papers by Leonard Hill, Jour. San. Inst., June, 1911, and Pop. Science Monthly, October, 1912, and in papers read before the Fifteenth International Congress on Hygiene by Lee (this Journal, Nov., 1912), and Kimball, Winslow & Henderson, (Eng. News, Nov. 28, 1912.)

istics or personal habits which are peculiar to them as a class we should expect this effect to show in the vital statistics of those cities in which a considerable proportion of the population are thus employed.

The four great textile cities in Massachusetts are Fall River, Lowell, New Bedford and Lawrence, with an aggregate population of over 400,000 people. In these cities the manufacture of textile goods is practically the only industry of importance, and in the various branches of this industry the great majority of the employed population of these cities is engaged. The returns of deaths from various causes in Massachusetts cities have been published annually in the reports of the State Board of Health since 1894. Comparing the returns of deaths from these four textile cities with those of the whole state during these seventeen years we find that the combined death rate from pneumonia and bronchitis was higher than that of the state in twelve of the seventeen years in New Bedford, in fourteen of the seventeen years in Lawrence, in fifteen of the seventeen years in Fall River and in each of the seventeen years in Lowell. Furthermore, the death rate from consumption was higher than that of the state in fourteen of the seventeen years in Lowell, in nine of the seventeen years in Lawrence, and in eight of the seventeen in New Bedford, and only in Fall River was the death rate from this cause lower than that of the entire state during a majority of the time since the records have been published.

In Table I are shown the average yearly death rates from respiratory diseases in each of these textile cities, in three cities in which the majority of employed persons are engaged in the manufacture of shoes, and in eleven other cities in which the industries are diversified or which are more residential in character, during the three five-year periods between 1896 and 1910. The average death rate from tuberculosis during these fifteen years was higher in Lowell than in twelve, and higher in Lawrence, Fall River and New Bedford than in nine of these other fourteen cities, and the average for the four textile cities is about 11 per cent. higher than that of the three shoe cities, and about 7 per cent. higher than that of the other eleven cities in the list. The difference in the combined death rates from pneumonia and bronchitis in these various cities is even more marked. The mean death rate from these two causes was higher in Lowell and Fall River than in any of the other cities in the table and the mean death rate in Lawrence and New Bedford was higher than in thirteen of these fourteen cities. Taking these cities in groups, the mean combined death rate from these two causes in the four textile cities during the fifteen years is more than 20 per cent. higher than that of the whole state, more than 60 per cent. higher than that of the three shoe cities and nearly 30 per cent. higher than that of the eleven cities having diversified industries.

During the past few years there has been a strong campaign for the prevention of tuberculosis throughout the country, and the effect of this is to

be observed in the average death rates for the three five-year periods for all the cities shown in the table. It is to be noted, however, that the reduction in consumption during recent years has been much less in the four textile cities than in the other groups of cities or in the state in general.

TABLE I.

AVERAGE DEATH RATES FROM RESPIRATORY DISEASES IN CERTAIN MASSACHUSETTS CITIES BY FIVE-YEAR PERIODS.

	Population, 1910.	Average Yearly Deaths per 1,000.					
		Tuberculosis.			Pneumonia and Bronchitis.		
		1896–1900.	1901–1905.	1906–1910.	1896–1900.	1901–1905.	1906–1910.
Textile Cities.							
Fall River	119,295	161	172	151	264	283	271
Lowell	106,294	214	164	154	288	280	290
New Bedford	96,652	163	178	139	240	269	263
Lawrence	85,892	139	176	166	228	265	262
Shoe Cities.							
Lynn	89,336	142	122	117	159	180	181
Brockton	56,878	183	161	99	124	105	120
Haverhill	44,115	199	173	140	205	199	209
Cities with Diversified Industries.							
Worcester	145,986	215	177	130	235	241	201
Cambridge	104,839	216	189	153	223	217	206
Springfield	88,926	181	145	102	200	162	185
Holyoke	57,730	161	180	146	175	227	233
Fitchburg	37,826	139	107	92	156	181	189
Taunton	34,259	224	219	168	235	261	299
Pittsfield	32,121	137	160	134	212	227	215
Waltham	27,834	194	161	114	167	189	206
Chicopee	25,401	174	127	117	230	209	255
North Adams	22,019	132	136	109	195	164	186
Northampton	19,431	192	143	129	192	138	180
Averages.							
Four textile cities	408,133*	169	172	152	255	276	272
Three shoe cities	190,329*	175	152	116	163	161	170
Eleven other cities	596,372*	179	159	126	202	207	214
Massachusetts	3,366,416*	189	164	140	229	210	220

* Total Population.

Factors Influencing the Health of Textile Operatives.

From these statistics it is apparent that respiratory diseases are more prevalent in the cities of Massachusetts where the majority of wage-earners

are employed in textile manufacturing plants than is the case in cities whose inhabitants find employments in other or in more diversified industries. We should, however, know something of the various factors which contribute to these results, in order to determine to what extent occupation rather than other factors are responsible. The various cities included in the tabulation were selected with the purpose of eliminating certain of these factors. Each of the textile cities is matched by one or more of the other cities in size and general character of population, in geographical location and in general climatic conditions, and in all of these cities sanitation is on practically the same plane. These factors then, while undoubtedly of a certain importance in individual instances, may be eliminated in a consideration of the question as a whole. Other factors which enter into the question are the personal characteristics and habits of the persons employed in the industry, and the environment in which they perform their daily tasks. With reference to the personnel of textile employees, the 1904 report of the Massachusetts State Board of Health states:

"It is, however, a fact which must not be slighted, that these industries are among the few that are open to persons of weak constitution and poor development. The work in the picking room, carding room, spinning room and weaving room is not of a kind that appeals to most vigorous men who can do better, financially and otherwise, in other lines of usefulness."

Personal habits, also may and probably do, enter into the question. Attention was called to this factor as long ago as 1895 by the late Sir Benjamin Dobson. In his book on Humidity in Cotton Spinning he says,

"I would suggest from my own knowledge that, beyond the question of the condition of the air in the mill, there is the question of the habits of the workpeople themselves; and I cannot help thinking that the mortality from these diseases might be much decreased if reasonably wholesome precautions were taken against chill by the workpeople themselves. But, as in every trade where there is personal danger, familiarity breeds contempt; and it is nothing uncommon to find workpeople coming from the hot mill to their homes for their meals, and after work is done for the day, when the outside atmosphere is at the extreme from the inside of the mill, with perhaps their shirt wet with perspiration and their chest open to the wintry breeze or the chilling fog. This may be done for a certain number of times with impunity; but the time will inevitably arrive when the border line of immunity is passed, and the accumulated weakness created by previous occurrences is the cause of a grave malady which may or may not be fatal, but even if not fatal, will make a serious breach in the general health of the sufferer . . . The female operatives are, perhaps, as daring in their defiance of the ordinary operations of natural laws; and it is no uncommon sight to see them trooping home in the cold of the winter evening with their mill clothing saturated with perspiration, and their only additional covering a shawl over the head and shoulders, which, although decent and picturesque, is a very inadequate protection against the extreme change of temperature. . . . In addition to this there is the ordinary spectacle in every mill yard, where, at intervals, men, women and children may be seen leaving the warm, dry, comfortable mill temperature, . . . with clothing hot and damp from the heat and perspiration, and cross to the water tap or for other purposes. Add to this bare feet, and I think you have some conditions, at any rate, that will explain the abnormal mortality from the particular class of disease I have mentioned."

This description of habits is as pertinent to Massachusetts mill operatives today as it was to English conditions at the time it was written. While the bare-footed workpeople do not have to "cross the yard to the water tap or for other purposes" in the modern mill, to see a considerable number of male operatives, clad only in overalls and undershirt, enjoying a noon-day smoke outside the mill gates, or a group of female operatives not much more warmly clad assembled at the wide open windows, even in the coldest and most inclement weather is an occurrence so common as to excite no comment in any textile city. Combined with "weak constitution and inferior development" this is undoubtedly an important factor in the causation of consumption, pneumonia and bronchitis. This habit of carelessness to exposure, however, is not peculiar to textile operatives and is to be observed to a greater or less degree in the workers in many other industries. Furthermore, the danger from carelessness of this sort can be reduced only by education of the people themselves, and cannot be controlled by legislation or by activity of the sanitary authorities.

Other factors instrumental in the cause of these diseases, and ones which are or may be controlled to a greater or less extent by legal measures, are those which pertain to the various manufacturing processes. The different textile processes and the conditions common to them, together with their relation to the health of employees, were discussed in detail in the report made by the Massachusetts State Board of Health in 1906. Following are abstracts from that report which fully illustrate the importance of these factors:

"It has long been known that work which involves constant confinement in a dusty atmosphere predisposes to the development of diseases of the lungs, especially of pulmonary consumption . . . Aside from dirt and other impurities which may be in the stock, it is the opinion of recognized medical authorities that vegetable dusts are markedly inimical to health. Those operatives in cotton mills who are peculiarly sensitive to unhygienic influences may become seriously affected through the constant irritation of cotton dust or "fly" in the upper air passages, giving rise first to dryness of the throat and later to cough and expectoration. Flax dust is thought to be even more irritating than cotton, while dust in the woolen and silk mills (animal origin) is considered to be somewhat less harmful in its effects. . . . We have to bear in mind also in considering the dust problem, the possibility of the presence of "infectious dust" from dried sputum in the air of different mill rooms. Persons suffering from consumption cannot always be detected in these rooms, and the habit of indiscriminate spitting involves the possibility of infection."

"There are many departments in which processes are conducted which expose the employees to dust; but the weaving, spinning, carding and waste rooms illustrate the important unhygienic conditions commonly associated with this disturbing element. In some weave rooms the air is so filled with dust as to present a hazy or "smoky" appearance. . . . Dust in spinning rooms is more constant and is greater in amount than in weave rooms. . . . In a course-goods mill, where waste stock is used in a low-studded and generally neglected room, the amount, constancy and character of the dust is such as to suggest the probability of real danger. The principal features of the card room are, the amount of dust, and lack of proper ventilation and effective means of removing the dust. . . . The quantity of dust is com-

monly sufficient to cause a distinct cloudiness of the atmosphere, which, in a room lacking proper ventilation, is a serious menace to the health of the operatives. In the assorting or waste room, "sweepings" are picked over and the different grades separated. Here may be found numerous kinds of waste and dirt, including that which comes from the floors of the card and spinning rooms, and, of most importance, sputum in large quantities, which may contain the exciting causes of infective diseases of the respiratory tract."

"In both weaving and spinning departments there are a number of other unsanitary influences which may affect the health of the workers, the effects of any one of which are not susceptible of correct measurement. . . . There is commonly an excess of moisture with unnecessary heat in weave rooms, and excessive heat with frequently undue moisture in spinning rooms. . . . Scarcely any effort is made on the part of most manufacturers to ascertain the definite conditions with respect to heat and moisture favorable to weaving. . . . The raising of humidity is done in a very unworkmanlike manner. . . . That heavy or excessive steaming in mills is injurious to the health of those who work in them has been for years the opinion of competent physicians. . . . Poor light is also a factor of no mean consequence in reducing the physiological resistance to disease. . . . It is impossible to ignore the probability that many individuals working in dirty, unpainted, overheated rooms, with impure air and excessive moisture, use up a great deal of nervous energy and suffer from eye fatigue or eye strain and its consequences."

"A room with poor light, unnecessary high temperature, dust, and an excess of moisture, is not, from a sanitary point of view, a desirable room to work in. . . . Add to these unhygienic influences two prominent factors which enter into health conditions, want of cleanliness and lack of provision for a plentiful supply of fresh air, and a class of rooms is represented which is conspicuously common among the weave and spinning mills in this State."

Reasons for Artificial Humidification.

It is now quite generally appreciated by mill managers that the humidity of the air is an important factor in the manufacture of textile fabrics. The former supremacy of certain English localities as textile centers was due to the naturally favorable climatic conditions, and the recognition of this fact led to the adoption of artificial means of increasing the moisture of the air in mills less favorably located. In this country the question of humidity received scant attention for many years. Within the last few years, however, systems of artificial humidification have been installed in practically all of the larger and more modern mills as well as in many of the smaller and older ones.

The fibrous materials used in textile processes are directly influenced by the presence and amount of moisture in their substance. When the fibers contain a certain proportion of moisture they are elastic and cling closely together and may be carded, combed, drawn out and spun into yarn, and woven into cloth, more easily than when dry. Under such circumstances the work in all these departments runs better and smoother, finer grades of goods may be made from the same stock, there is less waste, and the machines may be run at higher speed with less attention from the operatives. In a dry atmosphere the stock loses much of its moisture, the individual fibers become harsh, stiff and bristly and when drawn out and twisted into yarn

the ends stand out in all directions. Each fiber so lying outside the twist escapes its duty in contributing to the strength of the yarn. Electrification by friction, which is largely increased when the stock is dry, further contributes to this state by causing the fibers to repel one another. Yarn spun under these conditions is harsh and kinky, does not retain its twist, and breaks easily during the various manufacturing operations. Too much moisture in the stock, however, is a decided disadvantage in many of the operations. If the degree of moisture in the stock varies, as is the case when the natural humidity of the air fluctuates through any considerable range, a constant adjustment of the machines is required in order to keep the proper tension upon the yarn. As the temperature of the air increases, its affinity for water vapor also increases, and with higher temperature a greater relative humidity of the air is necessary to prevent the necessary moisture in the yarn from being lost through evaporation.

Much of the power used in textile mills is ultimately converted into heat. Much of this heat, however, is absorbed in the evaporation of water, the heat required for the evaporation of one pound of moisture per minute being equivalent to that generated by twenty-five horse-power of machinery. A proper system of artificial humidification, therefore, not only serves to correct the deficiency in humidity but also helps to control the temperature. With these facts in mind it is evident that the use of artificial humidification is a distinct advantage to the manufacturer. From the viewpoint of the operative also artificial humidification is desirable in many particulars. As the work runs more smoothly and evenly and there are fewer breaks and defects to watch for and repair, the tax on his nervous energy is greatly lessened, while the fact that dust and "fly" are appreciably reduced and much of the excess heat is absorbed contributes to his health and comfort. His earnings may also be increased to some extent, as he is enabled to turn out both more and better work. The temperature and humidity most suitable for obtaining the best results in each process with material of different character and quality have been determined with considerable care, and generally speaking have been found to be such as would not be unduly prejudicial to health. With the development of the artificial humidification idea, however, and the appreciation of its benefits, the disadvanatages of excessive moisture have frequently been overlooked, and amounts of humidity have been introduced which were not only detrimental to the work but also extremely bad for the workers. It is this feature, rather than any prejudice against the introduction of artificial moisture which has made laws limiting the amount of humidity necessary.

Methods of Increasing Humidity.

There are numerous types of apparatus for increasing the humidity of textile mills, some of which depend upon the introduction of moisture

directly into the mill rooms, and others upon treatment of the air forced into the rooms by some system of mechancial ventilation. The introduction of the moisture directly into the air of the mill rooms is the plan most commonly used in Massachusetts mills and was the only plan found in the mills covered by this investigation. From a sanitary viewpoint it makes little difference whether the moisture is introduced into the air before or after it reaches the mill room. The method by which the moisture is introduced, however, may have considerable sanitary significance. It is well known that when water vapor is produced by evaporation from a moist surface, all solid impurities are left behind. The mere fact that evaporation is accelerated by increasing the temperature of the water or air or both, or by bringing larger volumes of air in contact with the water, does not enter into the question provided the surface from which evaporation occurs does not become dry. On the other hand, a drop of water discharged into the air and evaporated before reaching the floor or other surface must completely disappear as water, leaving its impurities floating in the air. Moisteners constructed on this principle, therefore, introduce into the air those bacteria which existed in the water supply. This difference in effect is of the utmost importance, and has to be kept constantly in mind in any consideration of the quality of mill air.

The simplest method of producing artificial humidity in mill rooms is by sprinkling water upon the floor and trusting to natural evaporation. This method known as "degging" was widely practiced at one time, and is still used, or was until recently, in some foreign mills. This practice is objectionable to the operatives who believe that constant standing upon a wet floor is conducive to rheumatic troubles. Early improvements upon "degging" were the provision of shallow channels in the floor for the water or the placing of shallow pans of water about the room. Another practice, almost or quite as old as that of "degging" and one which is still used to a certain extent in some of the smaller and older mills, is that of introducing steam into the room. In some instances the steam is blown directly into the air, but usually the steam is turned into deep cans to prevent the dirty water and oil which it may carry from damaging the goods in the process of manufacture. The use of steam is objectionable for the reason that it unduly increases the temperature of the rooms.

The modern types of humidifying apparatus are all evolutions from one or the other of these older practices. There are two general types of modern apparatus in which natural evaporation from a moist surface is relied upon to increase the moisture of the air. In one of these the moist surface is supplied by cloths which are kept constantly saturated with water and in the other by plates over which a thin film of water is constantly flowing. In both cases the air is circulated among the cloths or plates by a fan or blower and considerable power is required for their operation. It

is claimed that apparatus properly constructed and operated on this principle not only adds nothing to the germ content of the air, but on the contrary should act as an air purifier by removing much dust, bacteria, etc.

The spray moisteners are made in a large variety of patterns. Some are constructed on the principle of the common household atomizer, water being sucked up and blowing into the air as a fine mist by a jet of steam or compressed air. In other types the water is thrown off as a fine spray from a brush or disk revolving at high speed in a box through which a current of air is forced. The types most commonly found in Massachusetts mills, however, are those in which a spray produced by a fine stream of water under high pressure passing through an orifice of special construction, or by the interference of two or more such streams, is projected directly into the air of the room. In apparatus of this character the spray nozzles are almost always located inside a housing and deflectors are provided to distribute the spray and to collect any water which is not atomized. The apparatus being open at the top, some air is drawn through this machine and is washed to a certain extent, but as no other mechanical means is used to ensure a circulation of air through the apparatus this effect is relatively small. In all of these types of apparatus, the excess water is usually collected and after being passed through a strainer or filter to remove the dirt is returned to the apparatus, and when the quality of water used for humidification is involved, as is the case under the Massachusetts law, the efficiency of such filters as well as the initial quality of the water supply of the mill has to be taken into consideration.

Scope and Methods of Investigation.

In the limited time and with the force at our disposal it was out of the question to attempt a complete investigation of all of the textile mills in Massachusetts. After a careful survey of the field, therefore, certain mills were selected for study in which all of the processes usually employed in the manufacture of cotton and woolen cloth were in operation and in which the range of conditions was thoroughly typical of those common to the cotton and woolen industry in Massachusetts. In all, the conditions in portions of six different mills, in which some 17,000 persons were employed were studied, four of these mills being engaged in the manufacture of cotton goods and two in the manufacture of woolen goods. In the trade there is a distinction between woolens and worsteds, and the processes of making them differ to some extent, but so far as the subject matter of this paper is concerned the conditions in the manufacture of each are quite similar, and the term "woolen" may be understood to include both. Furthermore, the distinction between cotton and woolen goods is not a sharp one from this viewpoint since the essential manufacturing operations in both branches

of the industry differ only in detail, and more or less cotton is mixed with the wool in the manufacture of many grades of so-called woolen cloth. While the manufacture of knit goods was not covered by the investigation, this branch of the textile industry differs from those studied only in the manner in which the yarn is interwoven to form a fabric, and the atmospheric conditions and requirements in the knitting room are not unlike those in the weave room.

Throughout the investigations determinations were made of the temperature, humidity and bacterial content of the air and analyses were made of the water used for humidification, and wherever filters or other apparatus for purifying this water were found, tests were made of the bacterial efficiency of such filters. In addition, data as to variations in temperature and humidity were obtained from the officials of certain mills in which more or less complete records have been kept, and comparisons of the readings of the various types of hygrometers with the standard instruments used in the investigation were made under actual mill conditions wherever such instruments were found installed.

The portion of the law limiting the degree of humidity applied only to the spinning and weaving departments, but that relating to the quality of the water used for humidification was less specific and might be construed to apply to all departments. For this reason while particular attention was given to the conditions in spinning and weaving rooms, the investigation was extended to cover typical conditions in practically all of the other rooms where humidifiers were used and, for purposes of comparison, examinations were made of the conditions in many rooms where there was no artificial humidification.

The sling psychrometer, in the modified form used by Soper in the study of air in the New York subway, was employed throughout for the determinations of humidity. This is essentially the standard instrument recommended by the United States Weather Bureau, but is constructed of aluminum and has an aluminum case with bayonet lock and carrying strap. The relative humidities corresponding to the difference between the actual (dry bulb) and the sensible (wet bulb) temperatures have been taken from the standard tables furnished by the United States Weather Bureau (U. S. Dept. Agr., W. B. Bull. No. 235). The humidity values given in these tables differ to some extent from those in tables supplied to the mill officials by the makers of many types of humidifiers and hygrometers, and from those stated in both the Massachusetts law and in the English regulations, all of which are based on the English or "Glaischer" tables.

After a careful comparison of a number of different methods for determining the numbers of bacteria in the air, it was decided to use the sand filter method, essentially as recommended by the A. P. H. A. Committee on Standard Methods of Air Analysis, and to make comparative tests

by the exposed plate method. As an added factor of safety, three sand filters were used in series in each determination instead of two as prescribed by the standard methods. The wisdom of adding the third sand tube was evident from the fact that a few bacteria were occasionally found in this tube which had passed through the first two tubes. The sand tubes were sterilized individually by dry heat and then fitted together with rubber connections which had been sterilized by alcohol. For convenience in handling each set of three connected filters was placed in a brass tube closed at each end by a rubber stopper. A large bicycle pump with reversed valves was used to draw the air through the filters, the capacity of this pump being calibrated each day. Some trouble was experienced at first by back-pressure from the pump disturbing the sand, this being finally eliminated by the insertion of a Bunsen valve in a small suction bottle filled with water between the pump and sand filter train. Fifty liters of air were drawn through the sand for each sample. During the first part of the investigation four plates were exposed for each sample, one with agar, one with litmus-lactose agar and two without media, agar and litmus-lactose agar being added respectively to the two dry plates after they were returned to the laboratory. As there was practically no difference in the counts on the wet and dry plates, and as the latter were far more convenient, dry plates only were used during the greater portion of the investigation.

As soon as the samples were received at the laboratory, the sand from each filter tube was mixed with 10 cc. of sterile water, shaken thoroughly, and after standing one minute for the sand to settle, fermentation tests and agar and litmus-lactose agar plates were made of the supernatant water. All agar plates were incubated four days at 20° C. and litmus-lactose agar plates eighteen hours at 40° C. before counting, both total and red colonies being counted on the latter. Moulds were counted on all plates when present. Fermentation tubes were incubated eighteen hours at 40° C., all positive fermentations being tested for the presence of B. coli by the regular Lawrence procedure. All counts by the sand filter method were multiplied by a factor, the results being expressed as bacteria, etc., per cubic meter of air. For the purpose of averaging results from different samples, all samples which contained less than 200 bacteria per cubic meter, *i. e.*, contained no bacteria in five liters, were assumed to contain 100 bacteria per cubic meter. The results of fermentation tests have been expressed as "+" or "0" in five liters of air.

In collectiong samples an ordinary camera tripod with an enlarged top was used as a support for the sand tubes and exposed plates, the intake of the sand tube and the exposed plates being located about two feet apart and about five feet above the floor.

(*To be concluded.*)

A DISCUSSION OF THE PROBLEM OF FISH LIFE IN CONTAMINATED STREAMS.

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Read before the Sanitary Engineering Section, American Public Health Association, Washington, D. C., September, 1912.

The writer regrets that it has not been possible for various reasons to present the result of experiments on fish life carried on by Mr. Langdon Pearse and the writer at the Sewage Testing Station of the Sanitary District of Chicago.

There is a distinct lack of precise experimental work on the relation of raw, settled, septic and biologically treated sewages or sewage mixtures, as well as trade wastes, to fish life in surface waters in this country.

The fundamental work on this subject has been undertaken by two Germans, Weigelt (Arch. Hyg. 1885) and König ("Die Verunreinigung der Gewässer," 1899, vol. 2). A few of the other observers were Richet, Haselhoff, Richter, Hofer, Kämmerer, Grandeau, Bert and Ohlmüller. Their investigation dealt principally with trade wastes. Weigelt observed the influence of putrid residential sewage upon trout, salmon and char in very exhaustive experiments. Hoppe-Seyler and C. Duncan (Z. physiol. Chem. 1893) demonstrated the effect of various amounts of oxygen in water upon trout and tench. Other observers of this phase of the problem were Jolyet and Reynard, Walter and Hofer. The work done by these men is of interest to ichthyologists here but should not be accepted as conclusive as far as American conditions are concerned. Even where the foreign experiments deal with the observations on the influence of certain chemicals added to the water upon fish life, the results may be applicable to our conditions only with certain limitations. Certain species common to surface waters here are rare abroad and species in which we are particularly interested have not been experimented on abroad at all. Now we know that various species will differ quite materially in their resistence towards chemical compounds or trade wastes and that even one and the same species inhabiting surface waters of different quality may show deviation in this respect. As far as sewage is concerned the European experiments are without doubt of little value to us. They deal with a much more concentrated liquid, which as a consequence decomposes quickly, forming products toxic to fish. The water-carrying capacity of our rivers is on an average much greater than abroad. Besides, here too we are interested in species uncommon in Europe.

In the American literature we strike occasionally references to casual observations on the relation of trade wastes to fish life but to the writer's knowledge no systematic attempt has been made to go into it thoroughly. Very meritorious work of this kind is done by the United States Bureau of Fisheries and it is to be hoped that others will take up investigations of this kind, which will prove of great importance to the fish industry in this country.

CERTAIN PHASES AND FALLACIES OF AMERICAN INFANT MORTALITY STATISTICS

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Prepared at invitation of, and read by title before the Section on Vital Statistics, American Public Health Association, Colorado Springs, September, 1913.

President Lincoln once sadly remarked that he supposed there never was a boy so fond of gingerbread as he had been who had gotten so little of it; and that observation might be paraphrased to apply to American vital statistics. Probably no other nation ever has shown so deep an interest in its vital statistics as the American people has displayed of late, or appropriated anything like as much money for their compilation, and, nevertheless, had so much trouble in securing even reasonably complete and reliable birth and death returns.

Of course, it is scarcely necessary to observe to the members of the American Public Health Association, the difficulty in securing adequate vital statistics for this country is by no means due to any shortcomings on the part of our national statistical headquarters, the Bureau of the Census, the decided expansion of the registration area and vastly improved returns of the last decade being largely due to the persistent and intelligent work of the Bureau's Division of Vital Statistics. The difficulties in the way of obtaining the desired data are fundamentally chargeable to two unique features of the American situation, to wit: (1) to our system of democratic government, including as it does half a hundred sovereign states, which in such matters are entirely independent; and (2) to the many and varied complications of the most cosmopolitan of all populations of modern times, in which practically all races and languages of the present era play more or less part. Owing to the constitutional limitations of this nation's central government, and the right of each state to say for itself how much or how little attention shall be paid to the compilation of its vital statistics, neither a national code nor an uniform set of state laws for the registration of births and deaths is possible. To make matters worse, more than one tenth—10.7 per cent.— of the American population at last reports consisted of negroes, for the most part illiterate; and an even 35 per cent. of the population of Continental United States according to the same authority, the Thirteenth Census, was either foreign-born or of foreign or mixed parentage, and hence more or less unfamiliar with the details of our language, our laws, and our customs. These two factors,

factors without a parallel in the case of any other nation, make the collection of this country's birth and death returns a veritable case of "confusion worse confounded."

Infant mortality might fairly be termed a special branch of vital statistics, and any man having even a bowing acquaintance with the branch in question will realize on a moment's thought that practically any and all of the difficulties in the compilation of vital statistics in general operate with special, intensified, force in the case of infant mortality statistics. Even in the lowest walks of life, the adult is invested with a certain individuality and is personally known to enough people to make it comparatively easy to obtain from one source or another sufficient data as to his name, nationality, occupation, age, cause and time of death, etc., for the death certificate required in all civilized communities of the Occidental world as an inevitable condition for a burial permit. With that mere human atom, the baby, the case is very different. Whatever distinctive character from the viewpoint of the proud father and mother the new arrival may possess, in so far as the busy, practical, outer world is concerned the average new-born is only one more embryonic individuality, which often disappears without leaving so much as a name behind it. Small wonder is it that, except with the most thoroughly systematized methods of birth and death registration as a guarantee against slips of omission, many a baby is born, and breathes a few hours, or days, or weeks, and dies—or even persists in living and growing up—without figuring at all in the vital statistics of his country. In the case of a nation confronted with so many and so unusual obstacles in the way of complete registration as is the United States, of course the possibilities of such oversights and the resultant defective vital statistics are materially greater than in practically any of the European countries where this phase of governmental work long since became thoroughly systematized. Taking into account our considerable negro population—especially in the Southern States, without the boundaries of the registration area—our congested foreign populations in many of the larger cities with extremely lax registration requirements, the vogue of midwife service in those city Babels under the loosest of supervising methods in many cases, obviously there are many phases of American infant mortality statistics which are indigenous and unfortunate.

The Real Utility of Infant Mortality Statistics.

A thoroughly up-to-date definition of the basic purpose of vital statistics, as now interpreted, was concisely stated by Dr. Reginald Dudfield, chairman of the Royal Statistical Society's Special Committee on Infantile Mortality, in the address before the Society on November 19, 1912, with which he opened the discussion of the Special Committee's voluminous report. As Dr. Dudfield put it: "Whatever may have been the original

aims and intentions of those who initiated the registration of births and deaths, there can be little room for doubt that at the present time the principal function of vital statistics, the natural outcome of registration, is the examination of the causes of unnecessary and preventable wastage of life and (but not to so general an extent) of sickness. Vital statistics may, in effect, be regarded as taking the place of laboratory experiments in social physiology and pathology. If such views be accepted as correctly representing the functions of statistics, it is evident that sound conclusions cannot be obtained unless the basic data are reliable and accurate, and the methods of calculations used by different inquirers uniform, or at least strictly comparable."

This definition of the principal function of vital statistics at the present time is exceptionally applicable to infant mortality statistics, the moving cause for the steadily increasing public interest in this phase of vital statistics, by common consent, being the growing conviction of the thinking community that not only the public conscience but the public welfare demand a careful study of the causes for, and vigorous action for the prevention of, unnecessary and preventable wastage of infant life. Dr. Dudfield's warning that "sound conclusions cannot be obtained unless the basic data are reliable and accurate, and the methods of calculations used by different inquirers uniform, or at least strictly comparable," even still more emphatically applies to the collection of statistical data regarding infant mortality.

As yet, there is practically not even a semblance of a basis on which to rest any tentative computation of the probable infant mortality rate of the United States as a whole. Any estimate, however expert, would be the merest guesswork, and it would be almost as hopeless to try to fix the infant death-rate for any section of the United States, or for any single state as a whole—with possibly two or three exceptions. In its discussion of infant and child mortality, *Bulletin 112* of the Bureau of the Census, presenting the annual mortality statistics for 1911 and recently issued, frankly concedes the hopelessness of the present statistical situation on these lines, thus stating the case: "Unfortunately, owing to the generally incomplete registration of births in the United States, it is impossible to present satisfactory rates of infantile mortality for the great majority of the states and cities. Even for the registration states—that is, the states in which the registration of deaths is regarded as at least approximately complete—and for many of the cities of 100,000 population and over this cannot be done."

This shameful fact—and it can only be considered a "shameful fact" when one of the greatest and wealthiest nations is compelled to plead guilty to it—is probably so generally known to the members of this Association that any further discussion of it at this time and place would be a

mere waste of words. Bad as it is, that is the condition which confronts us Americans, and the sole question, as I see the situation, is, what are the principal causes for this condition which are possibly remediable within reasonable time limits, and what are the practicable remedies?

The report of the Special Committee on Infantile Mortality, appointed by the Royal Statistical Society of London, was published in June, 1912, presented in great detail the results of the committee's exhaustive investigation of "the systems adopted in different countries for the registration of births (including still-births)and deaths with reference to infantile mortality," and in its appended tabulation of the responses from 103 registration officers to its inquiries undoubtedly supplies the most comprehensive and concise summary of the registration methods of the several states of this country ever furnished in printed form, in so far as I am aware. The tabulation of responses to the special Committee's various questions contains more or less specific answers from twenty-six states of this country, and with the exception of Iowa and North Carolina every one of these states answered "yes" to the leading question: "Is the registration of births and deaths compulsory?" Connecticut, Maryland, Massachusetts, Montana, New Mexico, North Dakota and Ohio, in their answers to the question, "What is the penalty for omission to register?" specifically name penalties for omission to register births, but the other states either make no answer to the question or make the ambiguous reply of naming a general penalty without showing whether or no it applies to non-registration of births or only to failure to register deaths. A footnote shows that the law of the District of Columbia applies to both births and deaths, and New York state now has a new law, which becomes operative on January 1, 1914, and provides for the registration of all births in the state within five days.

It might seem at first reading of these categorical replies from the registration officials of twenty-six states, or presumably persons authorized to answer for them, that at least approximately one half of the states of this country already had the laws necessary for the registration of births as well as deaths, but it is entirely unnecessary for anyone even casually familiar with the defective birth-registration of practically all of the states —with the possible exception of Massachusetts, Rhode Island and Connecticut—to take the trouble to read the responses of the various states to the driving question, "Do many births or deaths escape registration?" In other words, the evidence is conclusive that in the great majority of cases the American laws providing for compulsory registration of births as well as deaths are not actually enforced, and are practically dead letters. Apparently but one of two interpretations of such a state of affairs is possible, namely, that either the laws in question are so defective as to be unworkable, or that no serious effort to enforce the statutes is really made by the officials whose duty it is to enforce them. The latter interpretation

is, doubtless, the correct one in most if not all cases, and presumably the inaction of the officials concerned is primarily due to their suspicion that as yet there is no real public sentiment behind the laws for the registration of births. This *laissez-faire* official construction of the situation is probably correct in many if not most cases in point, but the public appreciation of the importance and varied utilities of birth registration is slowly but surely broadening, under the educational campaign inaugurated by this Association and many of its energetic members, and it now seems probable that a potent public sentiment in favor of a new order of things is gradually taking definite shape. While the present state of affairs in the matter of woefully defective birth-registration is deplorable, the clouds are lightening up, and the prospects are decidedly encouraging. For instance, in this, as in many other phases of the infant mortality campaign, the greatest of American cities is blazing the way, and quietly proving by actual results what can be done to better conditions, even in the most cosmopolitan—and in some places the most congested—city in the world. In 1910 the Department of Health of New York City instituted proceedings against forty-five physicians and midwives who had failed to report births in the city within the ten days named by the city's charter (Section 1237), and settled twenty-two of these cases upon payment of the penalty. It entered on 1911 with twenty actions pending and during the year brought 260 new actions, and by the end of the year had settled 233 actions on payment of the penalty. As an immediate outcome of the department's vigorous effort to enforce the law, it is believed that 95 per cent. of all the births in Greater New York are now annually registered.

A Bed-Rock Basis Imperatively Needed.

When a new "sky-scraper" is added to the maze of brick and stone and steel towers which has developed of late years at the lower end of Manhattan Island, the builders invariably sink their caissons so as solidly to rest on the bed-rock foundation of the metropolis, however far depressed the rock may be at that particular section of the island, and however much time, and labor, and money cost may be involved in the foundation work. Of course this method of sky-scraper building is not a builders' hobby, but a matter of sheer necessity. And a similar necessity confronts the would-be compilers of all safe and sound vital statistics; if their work does not rest on solid foundations, the higher they build the more the structure which they have created will be out of plumb.

In the compilation of general death-rates, as a rule practically complete returns of the deaths in the community are available, and, while actual census counts of population are not made in any case oftener than by five-years periods, long experience has qualified experts to estimate with reasonable accuracy the probable total population for any inter-censal year, thus

making possible the computation of a general death-rate with scarcely an appreciable margin of error. And except in the case of abnormally fluctuating populations, by similar processes corrected death-rates of approximate accuracy can be worked out by age-groupings of the population, the only serious danger of error being in the estimates for the very earliest ages. Even in census counts, the returns for the population under one year of age are confessedly unreliable and inaccurate. In his comments on infantile mortality, in the report on Vital and Social Statistics of the Eleventh Census, the late Dr. John S. Billings declared: "Unfortunately, these data are incomplete and inaccurate, not only for the United States as a whole, but for all parts of the registration area. This is due to the fact that the number of children returned as being under one year of age is too small in every locality, owing partly to omissions in the enumeration, and partly to the tendency of those reporting the age of infants to report those who are between nine and twelve months of age as being, in round numbers, one year old, which last is a defect common to the censuses of all countries."

The figure for the population under age 1 being entirely unreliable, whether based on census returns or on estimates for inter-censal years computed from those returns, it obviously follows that even the most carefully calculated infant mortality rates worked out by dividing the number of infant deaths by the supposed population under age 1 are necessarily incorrect, and of comparatively little value. On the other hand, if there is a complete registration of living births and deaths under age 1,—however short the period of life—the calculation of infant mortality by the division of the number of infant deaths by the number of living births rests on as solid a bed-rock foundation, as do the great sky-scrapers of New York City. For these reasons the vital statisticians of Europe long since discarded the former method of working out infant mortality rates as practically wort less, and concurred that the only reliable, scientific, method of calculating infant mortality is that of working out the ratio of infant deaths to living births. As the report of the Special Committee on Infantile Mortality, of the Royal Statistical Society, shows, Spain was the only nation in Europe reporting to the committee which then calculated its infant mortality on the basis of the ratio of deaths under age 1 to the supposed population under age 1. Anhalt, Saxe-Meiningen, Mauritius, Cuba and Uruguay were the only other divisions or countries in all the world, outside of this country, which reported their continued allegiance to the old-time method, but Indiana, Iowa, Maryland, Michigan, Minnesota, Nebraska, New Jersey, and Ohio similarly confessed. Practically all of the civilized world outside of the United States now calculating its infant mortality on the only rational, scientific, basis, the lack of the data needed to enable this country to fall into the procession of civilization and follow

the almost universally accepted course might almost be considered as one of the distinctive phases of American infant mortality statistics.

There is but one possible method of substituting the scientific for the unscientific process of computing the infant mortality of this country, and that, of course, is the collection of practically complete birth returns. Thanks to the determined educational efforts of the Bureau of the Census, of this Association, and of certain other intelligent influences, there are now abundant indications that this desideratum will sooner or later be attained. At least the younger members of this Association may even live to see the day when the vital statistics of the United States will have so far advanced as to justify their inclusion in the international records annually published in the reports of the registrar-general and other recognized European authorities on the world's vital statistics; but up to date the nearest approach to such recognition of the supposed vital statistics of one of the leading nations of the earth that the registrar-general's office has felt justified in making has been the publication in recent reports of a brief summary of population and death figures for the registration area furnished for the purpose by Dr. Cressy L. Wilbur, chief statistician of the Division of Vital Statistics of the Bureau of the Census. As a matter of course, Dr. Wilbur was compelled to omit from this tabulation any infant mortality figures for this country.

Some Distinctively American Statistical Shortcomings.

An unfortunate, but none the less inevitable, by-product of the steadily-improving registration of births in many states and cities of this country is the resultant inaccuracy in the yearly comparisons of the apparent birth rates and infant mortality rates for those states and cities. As the percentage of actual births duly registered increases, even though the real birth-rates and infant mortality rates remain absolutely unchanged the *apparent* infant mortality rate, of course, will decrease, and the *apparent* birth-rate increase, unless the gain through improved registration of births is more than offset by the general decline in the world's birth-rates or by immigration or other abnormal factors. By way of illustration, suppose that a city of an even 1,000,000 population were to have an actual birth-rate of 25 per 1,000, but that only 80 per cent. of its births were registered, thus making its apparent birth-rate 20 per 1,000. By the time the city's population had risen to 1,200,000 a constant birth-rate of 25 per 1,000 would mean 30,000 actual births, and if the birth-registration had by this time so increased that 90 per cent. were registered, the 27,000 reported births would have lifted the *apparent* birth-rate from 20 per 1,000 to 22.5 per 1,000. Should the actual birth-rate of 25 remain constant, the population increase to 1,300,000 and the percentage of registered births rise from 90 to 95 per cent., the city's vital statistics would record 30,875 births,

or a birth-rate of 23.75 per 1,000. In short, although the birth-rate in this hypothetical case had actually undergone no change whatever, the increase from 80 to 95 in the percentage of registered births would have resulted in apparently lifting the city's birth-rate from 20 to 23.7, thus showing a fictitious gain of 18.75 per cent., or nearly one-fifth, and making any annual comparisons of its supposed births and birth-rates grossly misleading.

It goes without saying that, even though the actual infant mortality rate of the city were to remain unchanged, the division of the annual returns for infant deaths by the improving annual returns for births would mean an *apparent* steady decline in the infant mortality rate, and thus make a true comparison of the annual infant mortality rates physically impossible unless in the earlier figures for registered births proper allowance was made to offset the improved birth registration. At the present time it is supposed that as high as 95 per cent. of all births actually occurring in New York City are registered, but Dr. William H. Guilfoy, the registrar of records, concedes that perhaps not more than 80 per cent. of births were registered as recently as 1900, and some authorities believe that the ratio of registered to actual births at that time did not exceed 65 per cent. In other cities the margin of improvement in birth registration in that same short period may have been even greater. On the basis of an increase in births registered from 65 to 95 per cent. of the actual number, there would be an apparent increase of 46.15 per cent. in a birth-rate actually remaining stationary, and in case of an increase from 80 to 95 per cent. in registration the apparent increase in a stationary birth-rate would amount to 18.75 per cent. Other things being equal, there would be corresponding decreases in the infant mortality rates although the infant mortality rate had actually remained constant. Do not these figures emphatically demonstrate one of the foremost fallacies of our American infant mortality statistics—except in the rare cases in which suitable allowance has been made for the changes in the percentage of birth registration?

That there has been a real decline in the infant mortality rates of the states and cities of this country, as there unquestionably has been for the most part in European countries, I do not for a moment doubt. The mere *decrease in the number* of infant deaths registered in the last few years—with the percentage of actual infant deaths registered undoubtedly increasing instead of decreasing—and the population in practically all cases steadily increasing—is the strongest possible proof of such a decrease in the ratios of babies dying to babies born alive. It might be argued at first thought by extreme conservatives that a declining birth-rate would possibly account for the decrease in the number of recorded infant deaths, even though there were no real decrease in the infant death-rate, but the more or less constant influx of immigrants to this country—in the main

made up of the most fertile of European peoples—probably has substantially offset the undoubted decline in the birth-rate of our native stock in recent years.

In its observations on infant and child mortality *Bulletin 112* of the Bureau of the Census positively asserts that "there has been a marked reduction in the infant death-rate in recent years." I am not sure that I have yet seen entirely satisfactory proofs of any such "marked reduction" in the case of any considerable number of American cities, but the entirely reliable English and German statistical records demonstrate that there undoubtedly has been such a reduction in the infant mortality rates of those countries, and probably the causes responsible for that reduction have also been operative in this country. In England and Wales the average infant death-rate for 1891–1900 was 153 per 1,000 living births, as contrasted with one of 127 for 1901–1910, and for the last four years the rates have been as follows: 1909, 109 per 1,000 births; 1910, 105 per 1,000 births; 1911, 130 per 1,000 births; 1912, 95 per 1,000 births. With the exception of 1911, when the trying summer period was unusually hot and dry, of late years the decrease in the infant mortality rates of practically all foreign countries with reliable records has been practically continuous.

That eminent authority on vital statistics in general, and infant mortality statistics in particular, Dr. Arthur Newsholme, medical officer to the Local Government Board for England and Wales, has recently supplemented his many notable contributions to the literature of infant mortality with a voluminous study presented in the Forty-Second Annual Report of Local Government Board, and in that report thus comments on the recent general decline in the infant mortality rates of his country:

"A dispassionate review of all the circumstances makes it highly probable that this decline has been, in large measure, brought about by the improved sanitary circumstances of urban populations, by increased attention to municipal and domestic cleanliness, by the education of mothers in personal hygiene, especially in regard to food and the care of infants, and by elevation of the standard of conduct and moral responsibility."

This calm and expert analysis of the causes for the recent reduction of England's infant mortality probably applies word for word, and comma for comma, to this country, although we have not as yet by any means as a nation gone about the reduction of infant mortality in the practically universal and thoroughly systematized manner in which England has tackled the job. In certain spots—especially in that greatest of American spots, New York City—we have seriously grappled with the problem, but not as yet on a nationalized basis. Within the limitations of its extremely narrow appropriation, the new Children's Bureau, at Washington, is trying to make a broad investigation of the various phases of the problem; the

New York Milk Committee, the American Association for the Study and Prevention of Infant Mortality, and various other promising agencies are coöperating, and the prospects are encouraging. Since 1910 the deaths under age 1 in Greater New York have dropped from 16,215 in that year to 15,053 in 1911, to 14,289 in 1912, and up to August 30 the total of infant deaths in New York City during the present year was but 9 551 as compared with 9,909 up to the end of the corresponding week of 1912, according to the tabulations of the Babies' Welfare Association, of New York. There can be no doubt that the excellent work of the Board of Health's Division of Child Hygiene in recent years, the fifty-five milk stations now maintained at municipal expense as an outcome of the New York Milk Committee's vigorous campaign in 1911, the twenty-two other milk stations now run by private agencies, and the systematized efforts of the recently organized Babies' Welfare Association are largely responsible for the decided decrease in infant deaths in New York since 1910.

Our Apparent Steady Increase in Infant Deaths from Wasting Diseases.

Despite all the strong indications of a probable decrease in this country's infant mortality rate in the last few years, in default of complete statistics of births and infant deaths we do not *know*, and cannot prove, that there has been a decrease in the infant death-rate for the country as a whole, though we can substantially so prove for certain large cities like New York and, perhaps, for Massachusetts and one or two other New England states. We have the total number of supposed deaths under age 1 in the registration area for each of the twelve years 1900–11, and the supposed numbers of these deaths due to each of the numerous recognized causes, but in default of accurate figures for the number of living births in each of these years we are necessarily more or less at sea as to whether the infant mortality rates for individual causes of infant deaths have really gone up or down. This fact is especially unfortunate in the case of that group of all important causes of infant deaths which Dr. Newsholme terms "developmental and wasting diseases," and which includes deaths charged to diarrhœa and enteritis, malformations, premature birth, congenital debility, and injuries at birth. As I have shown in one of the tables appended to this paper, the total number of deaths charged to these five causes in the registration area has increased from 55,558 in 1900 to 88,465 in 1911, but the mere increase in number would mean practically nothing in view of the steady increase in the registration area and its population and presumable number of births between the years 1900 and 1911. If the complete birth returns were available, it would be an easy matter to work out the ratio of deaths from each of these five causes to births, and, if there had been no important changes in the methods of reporting and classifying deaths under

these headings, we should then positively know whether the movement on these lines was upward or downward.

Having no birth returns for the registration area on which to work out the ratios in question, the one available method of attempting to determine the rise or fall in the curve of infant deaths from "developmental and wasting diseases" is to compute the ratios of the deaths assigned to these causes to the total reported numbers of infant deaths from all causes by individual years and periods, and then compare these ratios. So calculated, I find that the ratio practically has continuously increased, 49.7 per cent. of all recorded infant deaths in 1900 in the registration area having been charged up to these five causes, 59.2 per cent. having been so charged in 1911, and the ratio for the six-year period, 1906–11, having been 57.3 per cent. as against one of 51.4 per cent. for the six-year period, 1900–05. It is possible that quite a number of cases of premature births have latterly been so registered and consequently included among infant deaths though in the earlier years they might have been loosely classified as still-births and not reported at all. In his work on "Infant Mortality and Infants' Milk Depots," Dr. G. F. McCleary, of London, cited facts to show that the registered increase in England and Wales of deaths from premature birth was not entirely explicable by "a transference to the death register of children who would formerly have been buried as still-born," and it is extremely improbable that all, or anything like all, of the apparent increase of the number of deaths in the registration area from premature birth from 10,170 in 1900 to 23,539 in 1911 can be explained away on the theory that improved registration methods have latterly brought about the registration of large numbers of deaths from premature birth which formerly would have figured as still-births.

Certainly any such excuse would scarcely apply to deaths charged to malformations, congenital debility, and injuries at birth, and of course the record of deaths from diarrhea and enteritis stands practically unchallenged. Congenital debility is the only one of the five causes which shows any decline in the ratio of deaths so charged in the later six-year period, all four other causes show a decided increase in the later period, and the ratio of deaths charged to injuries at birth reveals a startling increase of 60 per cent. in the later six-year period as compared with the former six-year period, 2.4 per cent. of infant deaths from all causes having been so listed in 1906–11, although but 1.5 per cent. was thus charged in 1900–05. In the current July number of the *Journal of the Royal Statistical Society* Dr. Reginald Dudfield presents certain figures "On the Increase of Mortality from 'Injury at Birth,'" and shows that 846 deaths were so charged up in the infant mortality statistics for England and Wales for 1910, whereas but 603 were thus entered in 1901, and that for each 100,000 infant deaths in England and Wales in 1906–10 there were 820 due to injury at birth,

although in 1901–05 the proportionate number per 100,000 deaths from all causes was but 529. Dr. Dudfield says that "the results are submitted without any discussion of the causes of the increase, as that is a subject more suitable to a medical gathering. It will require some ingenuity to explain away the very great increase in mortality from this one cause—a cause which ought not to be operative except in very rare instances." The proportionate increase in the mortality from this cause in our registration area has not been quite so large as that shown for England and Wales by Dr. Dudfield's figures, but in both the five-year periods named our ratios of deaths from injury at birth to infant deaths from all causes were approximately three times as great as those of England and Wales, there having been 1,630 deaths from this cause in our registration area in 1901–05 as compared with 529 in England and Wales, and 2,257 as compared with 820 in 1906–10. It might seem that this comparison of our figures and the corresponding English figures is almost as surprising as are comparisons of the railroad accident and homicide rates of the two countries, and one which calls for serious attention from our American pediatric societies. I have heard exceedingly competent physicians express, at low breath, the opinion that the latter-day rush of American obstetrical specialists, their unwillingness to wait for nature to take its own course, and their tendency to use chloroform and forceps on the slightest provocation may have considerable to do with the extraordinary apparent increase in our ratio of deaths from injuries at birth. As Dr. Dudfield suggests, however "that is a subject more suitable to a medical gathering."

I have briefly reviewed several phases and fallacies of American infant mortality statistics which impress me as more or less distinctively American, but, aside from our lamentable and unique lack of even approximately complete birth returns, unquestionably the most distinctively American feature of our infant mortality statistics is the enormous population of alien races from all corners of the earth which figures in those statistics and the considerable population of utterly illiterate negroes. Surely no American could be accused of American boastfulness for asserting—or conceding, if you please—that the United States stands absolutely alone among the nations of the world from this viewpoint, and is confronted with an unprecedented conglomeration of problems naturally associated with its mixture of racial stocks. Fourteen years ago Newsholme recorded the fact that "of the 29,002,525 persons enumerated in this country (England and Wales) at the last census 961 per 1,000 were natives of England and Wales," and in 1896 Giddings announced that 979 of each 1,000 inhabitants of London were either natives of that city or other British possessions, only 21 hailing from foreign countries. Russia, Austria-Hungary, and Germany include various racial stocks in their populations—expecially Russia and Austria-Hungary—but their respective percentages of immi-

grant stock is practically *nil*. In the way of composite, foreign-blooded, population the United States does not now have any rivals, and never has had since the tide of immigration really started, 14.5 per cent., or just about one seventh, of its entire population in 1910 having been foreign-born, and 20.5 per cent. more of its population at the time being of foreign or mixed parentage. It is no easy matter to realize how powerfully this enormous foreign element, with its widely varying birth-rates and infant death-rates, figures in shaping our infant mortality statistics. By way of

TABLE I.

TOTAL POPULATIONS, AND POPULATIONS OF FOREIGN BIRTH OR FOREIGN OR MIXED PARENTAGE, OF THE TEN LEADING CITIES OF THE UNITED STATES IN 1910, AS REPORTED IN ABSTRACT OF THE THIRTEENTH CENSUS (p. 95).

Cities.	Total Population in 1910.	White Population.					
		Foreign-Born.		Foreign or Mixed Parentage.		Total Foreign-Born or of Foreign or Mixed Parentage.	
		Number.	Per Cent. of Total.	Number	Per Cent. of Total.	Number.	Per Cent. of Total.
New York	4,766,883	1,927,703	40.4	1,820,141	38.2	3,747,844	78.6
Chicago	2,185,283	781,217	35.7	912,701	41.8	1,693,918	77.5
Philadelphia	1,549,008	382,578	24.7	496,785	32.1	879,363	56.8
St. Louis	687,029	125,706	18.3	246,946	35.9	372,652	54.2
Boston	670,585	240,722	35.9	257,104	38.3	497,826	74.2
Cleveland	560,663	195,703	34.9	223,908	39.9	419,611	74.8
Baltimore	558,485	77,043	13.8	134,870	24.1	211,913	37.9
Pittsburgh	533,905	140,436	26.3	191,483	35.9	331,919	62.2
Detroit	465,766	156,565	33.6	188,255	40.4	344,820	74.0
Buffalo	423,715	118,444	28.0	183,673	43.3	302,117	71.3
Totals	12,401,322	4,146,117	33.4	4,655,866	37.5	8,801,983	71.0

shedding just a ray or so of light of this phase of the American infant mortality situation, I have appended to this paper certain tabulations showing (1) the foreign-born population and population of foreign or mixed parentage in each of the ten leading cities of the country in 1910, and the ratio of each element to the total population; and (2) the foreign-born populations of each of these ten cities hailing from those exceptionally fertile-stock countries, Russia, Italy, Austria and Hungary, and the percentage ratio of

these combined elements to each city's total population. Summarized in a sentence, the first table shows that about one third (33.4 per cent.) of the entire population of our ten leading cities is foreign-born, that another one third (37.5 per cent.) is of foreign or mixed parentage, and that, all told, 71 per cent., or more than seven out of every ten residents, of our ten leading cities is of distinctively foreign blood. In New York City, 40.4 per cent of the entire population of nearly 5,000,000 in 1910 was foreign-born, whereas in London 63 per cent. of the residents were born in the city, and about 34 per cent. in Great Britain outside of London.

TABLE II.

FOREIGN-BORN POPULATIONS OF THE TEN LEADING CITIES OF THE UNITED STATES IN 1910 RESPECTIVELY ACCREDITED BY THE THIRTEENTH CENSUS TO RUSSIA, ITALY, AUSTRIA AND HUNGARY.

Cities.	Persons Born in				Total Persons Born in These Four Countries.	
	Russia.	Italy.	Austria.	Hungary.	Number.	Per Cent. of Total Population.
New York	484,193	340,770	190,246	76,627	1,091,836	22.9
Chicago	121,786	45,169	132,063	28,938	327,956	15.0
Philadelphia	90,697	45,308	19,860	12,495	168,360	10.9
St. Louis	15,481	7,594	11,171	8,759	43,005	6.3
Boston	41,892	31,380	2,413	426	76,111	11.3
Cleveland	25,477	10,836	42,059	31,503	109,875	19.6
Baltimore	24,802	5,043	6,540	1,358	37,744	6.8
Pittsburgh	26,391	14,120	21,400	6,576	68,487	12.8
Detroit	18,644	5,724	14,160	5,935	44,463	9.5
Buffalo	11,349	11,399	9,284	2,442	34,474	8.1
Totals	860,713	517,343	449,196	175,059	2,002,311	16.1

In default of detailed birth-records for each city there is no known means of ascertaining even approximately how many births and infant deaths in the ten leading cities of this country are to be accredited to the four countries above named from which so large a percentage of the immigrants of recent years have hailed. But in order to show what an important part the populations of Russian, Italian, Austrian and Hungarian birth really play in those ten cities' infant mortality statistics, I have worked out a *purely hypothetical* tabulation showing how many births and infant deaths those elements of the population would have had in each case in 1910 if

TABLE III.

A CONDITIONAL SHOWING OF THE BIRTHS AND DEATHS UNDER 1 YEAR WHICH WOULD HAVE OCCURRED IN 1910, IN THE TEN LEADING CITIES OF THE UNITED STATES, AMONG THE FOREIGN-BORN POPULATION ACCREDITED BY THE THIRTEENTH CENSUS TO RUSSIA, ITALY, AUSTRIA AND HUNGARY, *IF* THE LATEST AVAILABLE BIRTH AND INFANT DEATH-RATES OF THESE COUNTRIES HAD BEEN MAINTAINED (see foot-note).

Cities.	Russian-Born Population.		Italian-Born Population.		Austrian-Born Population.		Hungarian-Born Population.		Total Presumptive Births and Deaths under 1 Year in Population Born in Russia, Italy, Austria and Hungary.						Total Births and Deaths under 1 Year in City.	
									Births.			Deaths under 1 Year.				
	Births.	Deaths under 1 Year.	Births.	Deaths under 1 Year.	Births.	Deaths under 1 Year.	Births.	Deaths under 1 Year.	Number.	Rate per 1,000.	Per Cent. of City's Total.	Number.	Rate per 1000 Births.	Per Cent. of City's Total.	Births.	Deaths under 1 Year.
New York	21,692	5,033	11,211	1,738	6,183	1,268	2,736	531	41,822	38.3	32.4	8,570	205	52.9	129,080	16,215
Chicago	5,456	1,266	1,480	230	4,292	880	1,033	200	12,267	37.4	....	2,576	210	37.6	....	6,844
Philadelphia	4,063	943	1,490	231	645	132	446	87	6,644	39.5	17.2	1,393	210	26.1	38,667	5,334
St. Louis	694	161	250	39	363	74	313	61	1,620	37.7	11.0	335	207	19.8	14,712	1,689
Boston	1,877	435	1,032	160	78	16	15	3	3,002	39.4	17.0	614	205	27.3	17,672	2,252
Cleveland	1,141	265	357	55	1,367	280	1,125	218	3,990	36.3	....	818	205	40.2	....	2,033
Baltimore	1,111	258	166	26	213	44	48	9	1,538	40.7	....	337	219	15.7	....	2,146
Pittsburgh	1,182	274	465	72	696	143	235	46	2,578	37.6	17.1	535	208	24.7	15,059	2,259
Detroit	835	194	188	29	460	94	212	41	1,695	38.1	14.2	358	211	16.7	11,960	2,138
Buffalo	508	118	375	58	302	62	87	17	1,272	36.9	12.7	255	200	15.7	10,008	1,623
Totals	38,559	8,947	17,020	2,638	14,599	2,993	6,250	1,213	76,428	38.2	....	15,791	207	37.1	....	42,533

The latest birth-rates per 1,000 population and death-rates under 1 year per 1,000 living births given for these countries in the Seventy-Third Annual Report of the Registrar-General for England and Wales, published in 1912, are as follows, the year for which each rate is given being stated in brackets: Russia (European), birth-rate (1905), 44.8, infant death-rate (1904) 252; Italy, birth-rate (1910), 32.9, infant death-rate (1909), 155; Austria, birth-rate (1910), 32.5, infant death-rate (1908), 205; Hungary, birth-rate (1910), 35.7, infant death-rate (1910), 194.

their birth-rates and infant death-rates in this country had been identical with those of the countries in which they were born. Citing from *Bulletin 112* of the Bureau of the Census the supposed figures for the total births and total infant deaths in each of our ten leading cities in 1910, I have attached these figures to the hypothetical tabulation of the births and infant deaths of the four foreign-born stocks named, and added the ratio

TABLE IV.

TOTAL POPULATIONS, NATIVE WHITE POPULATIONS OF NATIVE PARENTAGE, TOTAL WHITE POPULATIONS, AND NEGRO POPULATIONS, AND RATIOS OF EACH OF THESE GROUPS TO TOTAL POPULATIONS, IN TWELVE LEADING SOUTHERN CITIES IN 1910.

Cities.	Total Population.	White Population.				Negro Population.	
		Native, of Native Parentage.		Total White.			
		Number.	Per Cent. of Total Pop.	Number.	Per Cent. of Total Pop.	Number.	Per Cent. of Total Pop.
Baltimore	558,485	261,474	46.8	473,387	84.7	84,749	15.2
New Orleans	339,075	147,473	43.5	249,403	73.6	89,262	26.3
Washington	331,069	166,711	50.4	236,128	71.4	94,446	28.5
Louisville	223,928	113,543	50.7	183,390	81.9	40,522	18.1
Atlanta	154,839	91,987	59.4	102,861	66.4	51,902	33.5
Birmingham	132,685	66,312	50.0	80,369	60.6	52,305	39.4
Memphis	131,105	59,985	45.8	76,590	60.0	52,441	40.0
Richmond	127,628	69,130	54.2	80,879	63.4	46,733	36.6
Nashville	110,364	63,687	57.7	73,831	66.9	36,523	33.1
Savannah	65,064	22,634	34.8	31,784	48.8	33,246	51.1
Charleston	58,833	20,458	34.8	27,764	47.2	31,056	52.8
Jacksonville	57,699	22,628	39.2	28,329	49.1	29,293	50.8
Totals	2,290,774	1,106,022	48.2	1,644,715	71.8	642,478	28.0

of these hypothetical births and infant deaths to the totals in each case. It must be understood that I have included only the *foreign-born* populations in each case, and *not* included the populations of similar blood either of foreign or mixed parentage, and within these limitations the *purely hypothetical* tabulation shows that 76,428 babies would have been born to these foreign-born residents of our ten leading cities in 1910 if their native birth-rates and infant death-rates had been maintained, and that 15,791 of those 76,428 babies would have died in the first year, thus making a com-

TABLE V.

A DETAILED SUMMARY FOR THE TWELVE YEARS 1900–11, INCLUSIVE, OF ALL DEATHS UNDER AGE 1 FROM ALL CAUSES IN THE REGISTRATION AREA, AND INFANT DEATHS DUE TO DIARRHEA AND ENTERITIS, MALFORMATIONS, PREMATURE BIRTH, CONGENITAL DEBILITY, AND INJURIES AT BIRTH, AND THEIR AGGREGATE RATIOS TO TOTAL DEATHS UNDER 1 YEAR.

Years.	Total Deaths from all Causes.	Diarrhea and Enteritis.	Malformations.	Premature. Birth.	Congenital Debility.	Injuries at Birth.	Total Deaths from Five Causes Named.	
							Number.	Per Cent.
1900	111,687	27,627	3,227	10,170	13,484	1,050	55,558	49.7
1901	97,477	23,357	3,136	8,615	12,107	1,134	48,349	49.6
1902	98,575	21,912	3,165	9,087	12,724	1,304	48,192	48.9
1903	96,857	22,202	3,677	10,143	12,371	1,669	50,062	51.7
1904	102,880	25,286	4,046	11,361	12,640	1,899	55,232	53.7
1905	105,553	27,455	4,299	11,102	12,515	2,166	57,537	54.5
1906	133,105	35,220	5,857	14,250	15,493	2,543	73,363	55.1
1907	131,110	34,408	6,057	15,245	15,392	2,804	73,906	56.4
1908	136,432	37,049	6,525	16,441	15,833	3,110	78,958	57.9
1909	140,057	36,516	7,286	18,286	14,988	3,508	80,584	57.5
1910	154,373	44,695	7,501	20,275	12,048	3,725	88,244	57.2
1911	149,322	37,579	7,879	23,539	14,895	4,573	88,465	59.2
Totals	1,457,428	373,306	62,655	168,514	164,490	29,485	798,450	54.8
Six-Year Period, 1900–1905	613,029	147,839	21,550	60,478	75,841	9,222	314,930	51.4
Six-Year Period, 1906–1911	844,399	225,467	41,105	108,036	88,649	20,263	483,520	57.3

bined birth-rate of 38.2 and an infant death-rate of 207 per 1,000 living births for these four foreign-born elements in the population of the ten leading American cities. The total birth figures for some of these ten cities as given tentatively for what they are worth in the *Bulletin* of the Bureau of the Census are so palpably defective that it would have been entirely misleading to have worked out the percentage ratio of supposed births

TABLE VI.

A RECAPITULATION OF ALL DEATHS UNDER 1 YEAR IN THE REGISTRATION AREA IN 1900–11 DUE TO INJURIES AT BIRTH, AND THEIR ANNUAL RATIOS TO ALL DEATHS UNDER 1 YEAR FROM ALL CAUSES.

Years.	Total Deaths under 1 Year from all Causes.	Deaths under 1 Year from Injuries at Birth.	
		Number.	Ratios to Total Deaths under 1 Year.
1900	111,687	1,050	.94
1901	97,477	1,134	1.16
1902	98,575	1,304	1.32
1903	96,857	1,669	1.72
1904	102,880	1,899	1.85
1905	105,553	2,166	2.05
1906	133,105	2,543	1.91
1907	131,110	2,804	2.14
1908	136,432	3,110	2.28
1909	140,057	3,508	2.50
1910	154,373	3,725	2.41
1911	149,322	4,573	3.06
Totals	1,457,428	29,485	2.02
Six-Year Period, 1900–1905	613,029	9,222	1.50
Six-Year Period, 1906–1911	844,399	20,263	2.40

of the four foreign-born elements named to the alleged total births of the cities in question. But the infant death returns for those cities presumably are approximately correct, and in that event the infant mortality of the Russian, Italian, Austrian and Hungarian-born population of those cities, as *hypothetically calculated* on the basis of their native rates, would have amounted to more than one third, or 37.1 per cent., of the cities' total infant mortality. That is to say, a population amounting to only 16.1

per cent. of the ten cities' total combined population would have supposedly had 37.1 per cent. of the cities' entire infant mortality. And, it might be added, in the case of New York, Philadelphia, St. Louis, Boston, Pittsburgh, Detroit and Buffalo, whose birth returns are fairly complete, the babies which might supposedly have been born to the four foreign-born elements in question would have footed up to 24.7 per cent. of the total births. In a word, roughly speaking, a foreign-born population of less than one sixth of the total population of several of our largest cities might be expected to contribute about one quarter of the total births and more than one third of the aggregate infant mortality. I venture to believe that these tentative figures somewhat graphically show how important a part even the foreign-born Russian, Italian, Austrian and Hungarian elements in our ten leading cities play in American infant mortality.

To the appended tables above summarized I have added one more of a self-explanatory character, namely, a tabulation for the twelve leading distinctively southern cities of their several total populations, native-born white populations of native parentage, total white populations, and total negro populations. In the aggregate these figures show that the twelve foremost southern cities in 1910 had a native white population of native parentage amounting to nearly one half of their entire combined population (48.2 per cent., to be exact about it), a total white population of 71.8 per cent., and a negro population aggregating 28 per cent. of their total combined population. Taking into account the well-known fact of the exceptional negro fertility, the excessive negro infant mortality rate, the 28 per cent. negro population of the twelve principal southern cities, and the final fact that more than one tenth of the entire population of the United States is made up of negroes, the importance of the colored factor, as well as the foreign-blooded alien factor, in this country's infant mortality statistics would seem to be painfully apparent.

THE BACTERIOLOGY OF SOOT*

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The study of soot from a bacteriological standpoint has received but scant attention from the numerous investigators of the problems of the smoke nuisance.

Needless to say the subject has not been left out of the discussions; in fact, it is rather frequently mentioned in a more or less general way. As far as I have been able to ascertain, however, there has been but little definite work on the Bacteriology of Soot as discussed in this paper.

In an article in the *Revue Industrielle* (1), is found the question, "Are we going to learn one of these days that smoke, thanks to its antiseptic properties, contributes to making the atmosphere healthy?" Glinzer (2) refers to the fact that the particles contained in soot possess excellent germicidal and disinfecting qualities. Racine (3) in a discussion on the "Relation of Emphysema and Tuberculosis to coal-lungs in miners," believes from his own observations that anthracosis of the lungs acts as a protective influence against tuberculosis and that the only correct view is that coal has a great disinfecting power and that the conserving action of the coal dust is perhaps to be explained "from its action as a hinderance to the growth of micro-organisms such as the bacilli of tuberculosis." We were unable to find in the literature any original work upon which these conclusions could be founded. Percy Frankland (4) shows that fogs do not tend to concentrate or nurture bacteria, for he found there were remarkably few bacteria in London air during a fog. On the other side of the question, Russel (5) includes the increased number of bacteria in a list of contributory causes of the high death rates during fogs. Sir William Ramsay (6) first brought forward the theory that smoke by directly absorbing light, through the action of clouds and fogs, which are particularly fitted to absorb the blue, the violet and ultra-violet rays, which are the germicidal rays in light, contributes to the development and increase of bacteria, pathogenic as well as others, in the atmosphere. Liefmann (7) also believes that under the above conditions "bacteria, especially the pathogenic ones, are permitted to thrive." In passing it may be mentioned that there is no evidence that bacteria ever grow in the air. They are carried into it from a variety of sources, are continually falling out of it by gravitation, being carried out by rains, or destroyed in a number of ways. The effect of the gases in the

*This research was carried on in conjunction with the "Smoke Investigation" of the Department of Industrial Research, University of Pittsburgh.

air upon bacteria is another problem, although it is closely related to the one under discussion. The contamination of the air of our cities with sulphur dioxide is well known (8); also that sulphur dioxide in the air acts as a disinfectant, the necessary proportion being not less than 92 grams of sulphur per cubic meter (9). Cohen and Ruston in "Smoke—A study of town air," have devoted some space to the consideration of the effects of acid rains upon the bacteria of the soil. They point out that the greatest reduction takes place in the numbers and the activity of the nitrifying or nitrate producing bacteria, there being also a marked inhibitory effect on the nitrogen fixing organisms.

In our investigations we examined the air of Pittsburgh to determine the numbers and distribution of bacteria in different parts of the city and to ascertain, if possible, if any relation exist between the bacterial count and the smoke conditions.

For this purpose twenty glass evaporating dishes seven inches in diameter filled with agar-agar were exposed for from five to fifteen minutes in various districts. Notes were taken of the presence or absence of smoke, the wind direction, the condition of the earth whether moist or dry, and time of exposure. The number of colonies developing in forty-eight hours at 37° C. varied within very wide limits and it was found impossible to discover any influence of the smoke content of the air on the bacterial count. The difficulty of attempting to draw any definite conclusions from these experiments will be patent to everyone, the factors which influence the bacterial content of the air being so numerous and so variable as —rain, moist or dry soil, winds, sunlight, and other conditions. The map of the city shows the points where plates were exposed and Table I gives our findings in a condensed form.

One quite striking observation, however, was made and that was the comparative infrequency of the development of colonies around the soot particles. Rough macroscopic counts were made of the total number of visible soot particles and of those which were infected, as indicated by a black speck in the center of the colony. Out of about 500 counted, 100 showed growth. Many of these particles which we counted as soot, were, in all probability, specks of dust from other sources, so that our proportion of infected soot particles is too high. In several of the plates the soot particles were too numerous to count and around the majority of these no growth was to be noted. This was particularly true in the case of Plates 9 and 10, where the atmosphere was decidedly smoky. Considering the sources from which bacteria enter the air this is not to be wondered at. The smoke as it leaves the chimney is free from bacteria and apparently is not a favorable nidus for their collection from the air into which it is poured.

The common types of aerobic Gram positive spore-bearing bacteria and

TABLE I.

Plate Number See Map.	Time of Exposure in Minutes.	Weather.	Wind.	Smoke.	Count.	Notes.
1	15	Cloudy, rain 3 hrs. before.	N. W.	None	75	B. Coli Communis isolated.
2	15	Cloudy, rain 3 hrs. before.	N. W.	"	53	
3	5	Cool, cloudy; soil damp.	W.	"	15	
4	10	Cool, cloudy; soil damp.	W.	"	68	
5	15	Clear, warm; soil damp.	W.	Blowing towards plates but high.	26	B. Coli Communis. B. Coli Communior.
6	10	Bright sunshine; soil damp.	W.		43	B. Alkaligenes. Fecalis.
7	10	Cloudy, sultry; soil dry.	S.	Blowing towards plates.	51	5 soot particles, no growth.
8	15	Cloudy, sultry; soil dry.	S.		144	15 soot particles, 3 infected.
9	10	Partly cloudy.	S.	Smoky.	60	Soot particles very numerous, 1 infected.
10	15	Warm, dry.	S.	"	108	Soot particles very numerous, 3 infected.
11	5	Clear, warm, sultry; soil dry.	S.	Hanging low.	18	Several soot particles, no growth.
12	15	Clear, warm, sultry; soil dry.	S.	Same.	46	Few soot particles; 1 infected. B. Proteus Vulgaris.
13	10	Bright, hot, dry, sultry.	S.	Valley smoke not dense near plates.	59	No soot particles. Nocardia.
14	15	Threatening rain.	S.		—	Fly contaminated plate.
15	5	Threatening rain; rain 1 hr. before.	E.	Blowing towards plates.	116	B. Pyocyaneus. Soot particles 130; 14 infected.
16	8	Threatening rain; rain began.	E.	Same.	124	Soot particles 174; 17 infected.
17	10	Threatening rain; 2 hrs. before.	E.	Air smoky.	19	No soot particles.
18	10	Hot, clear, dry, dusty.	S. W.	Dirty, dusty, smoky.	196	Soot particles 11; 4 infected.
19	10	Hot, clear, dry, dusty.	S. W.	Valley smoky, clear near plates.	160	Soot particles 19; 11 infected; air nocardia.
20	5	Hot, clear, dry, dusty.	S. W.	Blowing towards plates.	131	Soot particles 72; 30 infected.
21	10	Hot, clear, dry, dusty.	S. W.	Blowing towards plates.	128	Soot particles 56; 14 infected.

MAP OF PITTSBURGH.

Showing Wards and Location of Agar Plates Exposed.

chromogenic organisms were isolated on our plates. B. Coli Communis and Communior, B. Alkaligenes Fecalis, B. Proteus Vulgaris, B. Pyocyaneus, and others, presumably from manure dust, and a few examples of air nocardia were also found.

Our next problem was to determine the action of soot on the growth of bacteria. For this purpose a quantity of soot was obtained from the special chimney in the Department of Industrial Research.

The partial analysis was as follows:

Tar	3.84%
Ash	1.19%
Fixed Carbon	94.97%

This specimen was used throughout the experiments.

The analyses of specimens of soot collected from the air in different parts of the city showed some wide variations.

Woods Run.	
Tar	0.82%
Ash	62.6 %
Fixed Carbon	36.58%
State Hall.	
Tar	0.36%
Ash	66.68%
Fixed Carbon	32.96%

This soot, even after standing around the laboratory in an ordinary cardboard box frequently open to the air, was shown by experiment to be almost free from bacteria. Five agar plates dusted with small quantities of this unsterilized soot failed to show growth with the exception of one colony on one plate. The soot was now added in varying amounts to test tubes of ordinary broth. No growth occurred. However, when larger quantities of this same soot were added to 150 cc. of broth in flasks, growth of bacteria did appear. The organisms developing being of the B. Subtilis group.

Experiments were next undertaken to determine the bactericidal action, suggested by the above observations. Efforts were made to determine any difference in growth in flasks of broth containing soot from other control flasks without soot. Dilution and plating methods were employed but the mechanical interference of the soot particles in the one case ruled out the method as one without even approximate exactness. The counts, however, were uniformly lower in the soot broth than in the control. A series of agar plates, one having the surface sifted with soot, the other free, were next exposed in the laboratory and counts made of the colonies from the aërial contamination. No marked difference in the number of colonies was found.

The following series of experiments have, however, given us quite definite results indicating a very marked bactericidal action of soot. Five grams of soot were thoroughly mixed with 100 cc. of broth 0.6 acid to phenolphthalein. After autoclaving, the mixture was allowed to stand several days. The soot particles were then filtered out and the filtrate after sterilization was seeded with B. Typhosus. A control flask was inoculated at the same time. No growth occurred in the soot-treated broth while a good growth developed in the control.

TABLE II.

Culture.	Soot Broth.	Control.
Staph. Albus	−	+ + +
Staph. Pyog. Aureus	−	+ + +
B. Coli Communis	+ +	+ + +
B. Coli Communior	+ +	+ + +
B. Mucosus Capsulatus	+	+ + +
B. Acidi Lactici	−	+ + +
B. Typhosus (3)	−	+ + +
B. Typhosus (90)	+	+ + +
B. Paratyphosus B.	−	+ + +
B. Paratyphosus Achard	+ +	+ + +
B. Dysenteriæ (Flexner)	−	+ + +
B. Pseudodysenteriæ	−	+ + +
B. Iliacus	−	+ + +
B. Proteus Vulgaris	+ + +	+ + +
B. Alkaligenes Fecalis	−	+ + +
V. Cholera	−	+ + +
B. Pyocyaneus	+ + +	+ + +
B. Indicus	+	+ + +
B. Subtilis	−	+ + +
B. Mesentericus	−	+ + +
B. Xerosis	−	+ + +
B. Diphtheriæ (230)	−	+ + +

(The intensity of the growth is indicated by the number of + signs.)

A second experiment was carried out. The broth after treatment with soot as before was tubed and inoculated with a series of organisms. Controls of plain broth from the same batch were used for comparison. Fresh twenty-four hour cultures were employed. The results are seen in Table II.

The soot broth tubes which showed no growth after seeding and incubation, did not show any growth on further transfers with the exception of B. Subtilis. The spores in this case had most probably withstood the

action of the bactericidal substance. B. Coli Communior and B. Indicus showed much less growth in the soot-treated broth than in the control. B. Pyocyaneus was apparently unaffected while B. Paratyphosus (Achard) and B. Proteus Vulgaris showed definite agglutionation in the soot-treated broth.

We believed that this inhibitory and bactericidal act'on was due to the phenols contained in the soot. The soot-treated broth gave a marked reaction for phenols by Millon's reagent while the control broth gave a negative reaction. After test'ng the acidity, phenolphthalein being used as the indicator, it was found that the soot treated broth gave a difference of 1.7 per cent. acid over the untreated broth, the acidity of which was 0.6 per cent. To determine whether this acidity was the potent inhibitory factor we carried out the following tests.

A new lot of broth was prepared and the reaction made 0.6 per cent. acid. To 500 cc. of this broth 25 grams of soot were added. The mixture was thoroughly shaken, autoclaved and allowed to stand for two days, with repeated shaking and finally filtered. The reaction titrated against N/20 sodium hydrate expressed in terms of hydrochloric acid was found to be 2.2 per cent. acid. One half of the broth was used at this acidity, 2.2 per cent. the other half being reduced to 0.6 per cent. by the addition of sodium hydrate. Half of the untreated control broth had its acidity raised to 2.2 per cent. acid with hydrochloric acid. The four lots were then tubed, sterilized and inoculated with a number of organisms from twenty-four hour agar slants. After an incubation of seventy-two hours, the results obtained were as shown in Table III.

From this it will be seen that we must consider at least two factors in the antiseptic action of the soluble content of soot in broth. The effect of the increased acidity which is seen most markedly in the cultures of the cholera vibrio where practically no growth took place in either of the acid broths is of great importance. The cholera organism is shown to be particularly sensitive to the presence of acid and for its cultivation an alkaline or neutral medium must be employed. Schroeder (10) has shown that the Vibrio choleræ is killed after an exposure of five hours to peat dust. It is especially effective, he says, if the peat dust be of an acid reaction.

The growth of B. Anthracis and B. Subtilis is also inhibited in the broths of high acidity, while B. Alkaligenes Fecalis and B. Iliacus, are definitely affected. It is interesting to note the effect of the acidity in interfering with the production of the coloring matter in the cultures of B. Pyocyaneus. Russel, Cohen and Ruston, and others point out the variable acid content of soot. On the other hand we notice, that, independently of the acidity, the soot-treated broth exercises a marked interference with growth. This is to be seen with B. Indicus, one strain of B. Coli Communis, B. Typhosus, and in B. Paratyphosus to a marked degree. The two latter organisms

are not generally affected by small amounts of acid, and are, therefore, valuable in testing out this second bactericidal effect of the soluble parts of the soot.

Soot probably has the power of absorbing many gases from the air especially those associated with the combustion of coal.

The next problem was to study the effect, if any, of soot on the destruction of bacteria in the process of dessication.

TABLE III.

Culture.	Control Broth. 2.2 Acid.	Soot Broth. 2.2 Acid.	Control Broth. 0.6 Acid.	Soot Broth. 0.6 Acid.
B. Indicus	Heavy cloud.	Trace of cloud.	Heavy cloud, heavy precipitate.	Slight cloud.
B. Pyocyaneus	Heavy cloud, powdery scum, trace of green color.	Same, no green color.	Same, bright green on top.	Heavy cloud, thick compact scum, green color throughout.
B. Anthracis	Clear, no precipitate.	Clear, no precipitate.	Clear, abundant precipitate.	Clear, slight precipitate.
B. Subtilis	No growth.	No growth.	Heavy ring, heavy precipitate, granular cloud.	Ring on glass, precipitate.
B. Coli Communis (52) and (14)	Marked cloud.	Slight cloud.	Marked cloud.	Slight cloud.
B. Coli Communis from urine (780)	Fair cloud.	Same.	Same.	Same.
B. Typhosus	Cloud.	Slight cloud.	Heaviest cloud.	Faint cloud.
B. Paratyphosus B.	Marked cloud.	Faint cloud.	Marked cloud.	Faint cloud.
B. Proteus Vulgaris	Heavy cloud, no scum.	Heavy cloud, scum.	Very heavy cloud, no scum.	Very heavy cloud, scum.
B. Iliacus	Slight cloud.	Fair cloud.	Heaviest cloud.	Heavy cloud and ring.
B. Alkaligenes Fecalis	Faint cloud.	Clear.	Marked cloud, scum.	Slight cloud.
V. Cholera	Clear.	Trace of cloud.	Cloud.	Cloud.

Dessication is one of the most valuable natural means of disinfection and many organisms succumb to its effects very rapidly as the gonococcus, the B. Influenza, the meningococcus and others. The micro-organisms of the air, on our streets, and in our houses are continually being destroyed by this process and we have been able, we believe, to show that soot increases very decidedly, this bactericidal action.

TABLE IV.

Exposure.	Influence of Soot on B. Indicus.		
	Control. Cover Glass. Dipped in Broth and Dried.	Cover Glass I. Dipped in Soot while Moist, then Dried.	Cover Glass II. Dried as in Control. Buried in Soot.
1 day	+	+	+
2 "	+	+	+
3 "	+	+	+
4 "	+	−	+
5 "	+	−	+
7 "	+	−	−
8 "	+	−	+

(The + sign indicates that growth was obtained in the test cultures.)

TABLE V.

Exposure.	Influence of Soot on B. Typhosus and Streptococcus Fecalis.			
	Culture.	Control. Dipped in Broth and Dried.	Cover Glass I. Dipped in Soot while Moist, then Dried.	Cover Glass II Dried as in Control. Buried in Soot.
2 days	B. Typhosus	+	−	
	S. Fecalis	+	+	
3 "	B. Typhosus	+	−	+
	S. Fecalis	−	−	−
	B. Typhosus	+	−	+
	S. Fecalis	+	−	+
4 "	B. Typhosus	+	−	+
	S. Fecalis	−	−	+
5 "	B. Typhosus	+	−	+
	S. Fecalis	+	−	−
6 "	B. Typhosus	+	−	+
	S. Fecalis	−	−	−
9 "	B. Typhosus	+	−	+
	S. Fecalis	−	−	−
10 "	B. Typhosus	+	−	−
	S. Fecalis	+	−	−

The technique of our experiments was as follows: Fresh twenty-four hour-broth cultures of the organisms to be tested were prepared. Small sterile cover glasses were thoroughly moistened by dipping them into the cultures. These were dried under sterile precautions for sixteen to twenty-four hours over caustic soda. They were then transferred to sterile petri dishes and used as controls.

Cover glasses indicated under the heading I in the table, were dipped into the broth cultures and then into sterile soot and finally dried as in the control. Cover glasses under heading II in the table were prepared in the same way and at the same time as the control, and when dry were packed in sterile soot. From time to time these cover glasses were dropped into tubes of dextrose broth to test the viability of the organisms.

It will be noted that the failure of growth is shown very clearly in the case where the moist cover glass was dipped in soot and then dried. In the majority of cases those cover glasses which were first dried and then packed in soot failed to show growth much later than the above, but usually before the control. This is well shown in Table V.

The long period that the Streptococcus Fecalis, 174 days, and Staphylococcus Pyogenes Aureus, 225 days, remained viable under these abnormal conditions, is quite remarkable. (See Table VI.)

In Table VII is shown the peculiar behavior of yeast. It survived longest, 41 days, on the cover glasses dipped in soot while still moist, the conditions under which all the other organisms tested rapidly died out. Marshall (11) quotes Hansen as stating that compressed beer yeast mixed and dried with charcoal kept as long as ten years. The marked resistance of the yeast organism to the action of acids is also of importance in this connection.

The great natural disinfectant of the atmosphere and our surroundings is the bactericidal action of the sun's rays. Direct sunlight is most destructive and its activity upon bacterial life depends directly on the amount of moisture and dust in the air.

Smoke, in contributing very great numbers of minute particles to the air, adds to the conditions favoring fogs and clouds. Smoke, fogs, and clouds, all absorb more or less, the blue, the violet, and ultra-violet rays of the sunlight. This is well seen in the familiar red sun of a smoky atmosphere. These particular rays, which are absorbed, give the important bactericidal action to the sunlight. Most of the above facts have been amply proved by other experiments and it was not considered advisable to repeat them. We have, however, made a few observations on the protective action of soot for bacteria.

The technique of our experiments was briefly as follows: Agar-agar, well seeded with the test organism, was poured into petri dishes. Soot was sifted over one half of the cover of the petri dish while the other half re-

TABLE VI.

Time of Exposure.	Incubation Period.	Influence of Soot on B. Coli, B. Typhi, Streptococcus Fecalis and Staphylococcus Aureus.			
		Culture.	Control. Dipped in Broth and Dried.	Cover Glass I. Dipped in Soot while Moist, then Dried.	Cover Glass II. Dried as in Control. Buried in Soot.
2 days.....	24 hours	B. Coli	+	+	
		B. Typhosus	+	+	
		Strep. Fecalis	+	+	
		Staph. Pyog. Aureus	+	+	
5 "	24 "	B. Coli	+	−	+
		B. Typhosus	+	+	+
		Strep. Fecalis	+	−	+
		Staph. Pyog. Aureus	+	−	+
	48 "	B. Coli	+	+	+
		B. Typhosus	+	+	+
		Strep. Fecalis	+	−	+
		Staph. Pyog. Aureus	+	−	+
6 "	24 "	Strep. Fecalis	+	+	+
		Staph. Pyog. Aureus	+	−	+
7 "	24 "	B. Typhosus	+	−	+
		Strep. Fecalis	+	+	+
19 "	24 "	B. Coli	+	−	+
		B. Typhosus	+	−	−
		Strep. Fecalis	+	−	+
		Staph. Pyog. Aureus	+	−	+
	48 "	B. Voli	+	−	+
		B. Typhosus	+	−	−
		Strep. Fecalis	+	+	+
		Staph. Pyog. Aureus	+	−	+
34 "	24 "	B. Coli	+	−	−
		B. Typhosus	+	−	−
		Strep. Fecalis	+	−	+
		Staph. Pyog. Aureus	+	−	+
	48 "	B. Coli	+	−	−
		B. Typhosus	+	−	+
		Strep. Fecalis	+	−	+
		Staph. Pyog. Aureus	+	−	+

TABLE VI (*Continued*).

Time of Exposure.	Incubation Period.	Influence of Soot on B. Coli, B. Typhi, Streptococcus Fecalis and Staphylococcus Aureus.			
		Culture.	Control. Dipped in Broth and Dried.	Cover Glass I. Dipped in Soot while Moist, then Dried.	Cover Glass II. Dried as in Control. Buried in Soot.
62 days.....	24 hours	B. Coli	+	−	−
		B. Typhosus	−	−	−
		Strep. Fecalis	−	−	−
		Staph. Pyog. Aureus	−	−	−
	48 "	B. Coli	+	−	−
		B. Typhosus	−	−	−
		Strep. Fecalis	+	−	+
		Staph. Pyog. Aureus	+	−	+
174 "	24 "	Strep. Fecalis		−	+
		Staph. Pyog. Aureus	−	−	+
225 "	24 "	Staph. Pyog. Aureus	+	−	−
247 "	24 "	Staph. Pyog. Aureus	−	−	−

mained free. These plates were then exposed to the sunlight for definite periods, then incubated and the results read.

A number of plates, seeded with Staphylococcus Aureus, were exposed to sunlight for varying periods every day for two weeks. The results obtained are shown in Table IX. Notwithstanding the irregularity of these results the protection, afforded by the soot in the air and clouds against the action of the sun's rays, is, I believe, clearly shown.

There are a number of very interesting questions which arise as a result of these experiments. It has been shown that soot in contact with bacteria has very decided bactericidal properties. These properties are also demonstrated in the soluble content of the soot. The soot particles from the air as they fell on our plates were generally sterile. This may be due to the solution of the bactericidal substances of the soot by the moisture on our plates, with the consequent destruction of any bacteria adherent to the soot. Or the moisture condensing around the soot as it does in the formation of fogs and clouds, may have acted in the same way before it was collected on our plates. The third possibility is that the majority of the soot

TABLE VIII.

Organism Tested.	Inhibition of Solar Bactericidal Activity.			
	Time of Exposure.	Incubation.	Soot Covered Half.	Unprotected Half.
Strep. Fecalis	5 mins.	24 hrs.	Few colonies	None
	5 "	48 "	Many "	Many colonies
	15 "	48 "	Few "	No growth
	30 "	48 "	Few "	Many colonies
	45 "	48 "	Few "	Many "
	45 "	48 "	Many "	Few "
	120 "	48 "	Many "	Few "
B. Indicus	10 "	48 "	Many "	Many "
Staph. Aureus	10 "	48 "	Many "	Many "
	30 "	48 "	Many "	Many "
	45 "	48 "	Many "	Few "
	75 "	48 "	No "	No "
B. Mesentericus	15	48 "	Few "	Few "
	30 "	48 "	Few "	Few "
	45 "	48 "	Few "	Few "
	60 "	48 "	Few "	Few "
	75 "	48 "	Few "	Few "
	180 "	48 "	Few "	Few "

substances from the soot in crevices and corners must be very high. We have found, as others have demonstrated that the effect of soot in fogs and clouds in diminishing the action of the sun's rays on bacteria, is quite definite. The relative importance of the protective qualities of soot against sunlight to the bactericidal effect of the constituents of soot remains an open question.

There are, therefore, two divergent results brought about by the presence of soot in our atmosphere and upon the earth's surface. One of these is beneficial and the other harmful to the life of vegetable micro-organisms, and from the bacteriological and hygienic point of view may serve as a direct aid in propagating or preventing the spread of infectious disease.

General Conclusions.

1. Soot has a definite bactericidal action on bacteria, due either to the absorption of moisture from the organisms or more probably to the action of its contained germicidal acids and phenols.

2. Soot as it exists in the air does not form a favorable nidus for the collection and distribution of bacteria.

particles never came in contact with bacteria after leaving the chimney, at which time they were, of course, bacteria free.

That this disinfectant substance requires moisture in order to have its most powerful effect is well shown in the drying experiments where the organisms treated with soot, while still moist, succumbed very much sooner than the others. There is also the possibility that the soot absorbs

TABLE VII.

Time of Exposure.	Incubation Period.	Influence of Soot on B. Diphtheriæ and Yeast (Saccharomyces).			
		Culture.	Control. Dipped in Broth, then Dried.	Cover Glass I. Dipped in Soot while Moist. Dried.	Cover Glass II. Dried as in Control. Buried in Soot.
3 days.....	48 hours	B. Diphtheriæ	+	−	
		Yeast	+	+	
	72 "	B. Diphtheriæ	+	+	
		Yeast	+	+	
7 "	24 "	B. Diphtheriæ	+	−	+
		Yeast	−	−	−
	48 "	B. Diphtheriæ	+	−	+
		Yeast	+	+	+
	72 "	B. Diphtheriæ	+	+	+
		Yeast	+	+	+
16 "	48 "	B. Diphtheriæ	+	−	+
		Yeast	−	+	+
	72 "	B. Diphtheriæ	+	+	+
		Yeast	−	+	+
27 "	72 "	B. Diphtheriæ	+	−	+
		Yeast	−	+	−
38 "	48 "	B. Diphtheriæ	+	−	+
	5 days	B. Diphtheriæ	+	+	+
41 "	48 hours	B. Diphtheriæ	+	−	+
		Yeast	−	+	−
77 "	72 "	B. Diphtheriæ	−	−	−
		Yeast	−	−	−

moisture from the bacteria and hastens thereby its death by thorough drying. This was suggested in the experiment in which dried organisms were buried in soot and frequently killed off earlier than in the control.

That the conditions, similar to those of our experiments, are to be found in every smoky city, will be evident to any one who has noticed the black, smeary deposit of soot on damp days where the concentration of soluble

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Organism Tested.	Inhibition of Solar Bactericidal Activity.			
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	5 "	48 "	Many "	Many colonies
	15 "	48 "	Few "	No growth
	30 "	48 "	Few "	Many colonies
	45 "	48 "	Few "	Many "
	45 "	48 "	Many "	Few "
	120 "	48 "	Many "	Few "
B. Indicus	10 "	48 "	Many "	Many "
Staph. Aureus	10 "	48 "	Many "	Many "
	30 "	48 "	Many "	Many "
	45 "	48 "	Many "	Few "
	75 "	48 "	No "	No "
B. Mesentericus	15	48 "	Few "	Few "
	30 "	48 "	Few "	Few "
	45 "	48 "	Few "	Few "
	60 "	48 "	Few "	Few "
	75 "	48 "	Few "	Few "
	180 "	48 "	Few "	Few "

substances from the soot in crevices and corners must be very high. We have found, as others have demonstrated that the effect of soot in fogs and clouds in diminishing the action of the sun's rays on bacteria, is quite definite. The relative importance of the protective qualities of soot against sunlight to the bactericidal effect of the constituents of soot remains an open question.

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TABLE IX.

(Inhibition of Solar Bactericidal Activity by Smoke. Test Organism Staphylococcus Pyogenes Aureus)

	Sun.	Clouds.	Smoke.	Result.	Note.
1	Bright		Clouds low.	Killed 1 hr.	
2	Dull	Present.	Clouds passing over sun.	Slight difference in 1 hr.	
3	Bright	Passing across sun.	None.	Killed 1 hr.	24 hr. incub.
4	Bright	Same.	"	Lessened in 15 and 30 mins. in proportion.	
5	Hidden, dull	Snowing in morning. Present.	"	Killed in 1½ hrs.	
6	Bright	Thin and white.	Around horizon.	Not killed in 1 hr., lessened.	
7	Clear	—	Haze around horizon.	Same.	
8	Bright and clear	Very few.	—	35 mins., much lessened; 1 hr., almost all killed.	
9	Bright and variable ..	Cloudy.	—	Not killed in 1 hr.	
10	Bright	None.	Much, low down.	Not killed in 1 hr.	Around edge.
11	Dull, foggy.	Foggy.	—	Little change in 1½ hrs.	
12	Dull	Many, raining.	Much.	Almost all killed in 1½ hrs.	
13	Variable, free, dull	Variable.	—	Little change 1¾ hrs.	
14	Bright	None.	Haze.	Killed in 1 hr.	

3. Broth and other fluids treated with soot have conferred upon them a decided germicidal power.

4. This germicidal action is due not only to the acids contained in the soot but also to some other agent, probably some of the phenols.

5. Soot, as it occurs in smoke, clouds, fogs, and as a non-transparent covering for our streets and houses, protects micro-organisms from the destructive action of the sunlight.

I wish to express my thanks to Mr. C. H. Marcy for his valuable assistance in the early part of the work, more especially in the study of the

bacteriology of the air of Pittsburgh. I wish also to thank Dr. O. Klotz for many suggestions and Mr. Benner for the samples of soot and the chemical analysis of the same.

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Bibliography.

1. Revue Industrielle, November, 1890.

2. C. Glinzer, "Address on the Smoke-Nuisance and its Abatement," before the Industrial Society of Hamburg, 1890.

3. Racine, Vierteljahrsschrift für Gerichtliche Medicin, New Series, Vol. 40–41.

4. Quoted by W. J. Russel, "Town Fogs and their Effects." Nature, 1891, XIV, p. 10.

5. F. A. Rollo Russel, "The Atmosphere in Relation to Human Life and Health." Smithsonian Report, 1895.

6. Quoted by Liefmann.

7. H. Liefmann, "The Smoke and Soot Question Especially from the Hygienic Point of View." Hall, 1908.

8. Theo. W. Shaefer, "The Contamination of the Air of our Cities with Sulphur Dioxide, the Cause of Respiratory Disease." Boston Medical and Surgical Journal, Vol. 157, 1907.

9. "How much Carbolic Acid or how much Sulphurous Acid is Necessary for the Destruction of the Smallest Form of Life?" Vierteljahrsschrift für Gesundheitspflege. Vol. XII, 1879.

10. Schroder, J. Society Chem. Ind., XIII, 538.

11. Marshall, Microbiology, Philadelphia, 1911.

THE HUMANE AND SANITARY DISPOSAL OF SUPERFLUOUS ANIMAL LIFE.

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In all conditions and surroundings of human life, in all countries, and among all men, there is a parallel and intimately connected line of animal life, that in a sense forms a part of the scheme of human existence. The domestic animals are a necessary factor as food for sustaining human life or as beasts of burden to bear a part of the heavy labor, or as our companions or associates in many intimate relations, they contribute in no small degree to our happiness and amusements.

But their span of life is short, and presently they become old and decrepit and finally an incumbrance to be mercifully disposed of.

Besides the smaller animals that pass their whole life as household pets and companions there is a far larger number that for various reasons are separated from or abandoned by their owners or protectors to become a public charge and to lead a precarious existence often attended with great suffering.

In most large cities these hapless victims of men's negligence or cruelty are cared for by the Humane and Benevolent Associations that are supported by voluntary contributions. As a rule the municipal authorities do not concern themselves with this question, except, when absolutely compelled to, they may provide a pound or receiving station where they are held for a short time and then destroyed by the most convenient means.

While the societies endeavor to find comfortable homes for the best animals that come into their possession, still the life of a far larger number must be ended immediately after they are received because of sanitary conditions, or the cost of their care, and often as a merciful termination to a life of suffering.

The methods in use are varied according to the custom or practice of each association. Slow strangulation by illuminating gas or the fumes of charcoal, the administration of active poisons and chloroform or death by shooting are the means commonly used. All these are open to objection, because of the greater or less period of suffering to the animal, or are attended by danger to the health or life of the operator. All leave much to be desired from the sanitary viewpoint, and they are abhorrent to persons of humane and sympathetic feelings.

To discover a method that would overcome these objections, at least to a large degree, and that would be at the same time simple and economical in operation, has been the purpose to which the inventor of the automatic

electric cage has given nearly four years of careful thought and study. His invention has taken its present shape as the result of a long series of trials with different forms of apparatus that have been rejected one after another on account of defects that would not stand the tests of experience. From the outset there was no difficulty in destroying animal life humanely by means of electricity. It was quite another matter to construct a machine that would be automatic in action, that could be operated by any fairly intelligent workman, and that would not, on the one hand, put a needless nervous strain on the operator, or, on the other, endanger his safety. After the most exacting tests, involving the humane destruction of many thousands of animals, the inventor now feels confident that this apparatus has reached a final and definite form.

The Animal Rescue League is a Society formed in 1899 for the protection of animals from cruelty, the relief of their suffering, for their care during their life, and for the disposal of their bodies.

It owns and occupies a large home, 51 Carver Street, Boston, just out of Boylston Street at the foot of the Common where the general work of the League is carried on. There are large enclosed yards, many rooms for the various classes of animals and ample space for reception, examination and oversight of the smaller animals, together with the electric cages and crematory for their final ending.

During the past year more than 23,000 cats and kittens, 5,454 dogs, 175 horses, besides birds and rabbits and squirrels have passed through the hands of the League.

The League owns a country annex and home for horses at Pine Ridge, just outside Boston, and has five branch receiving stations at various points in the city.

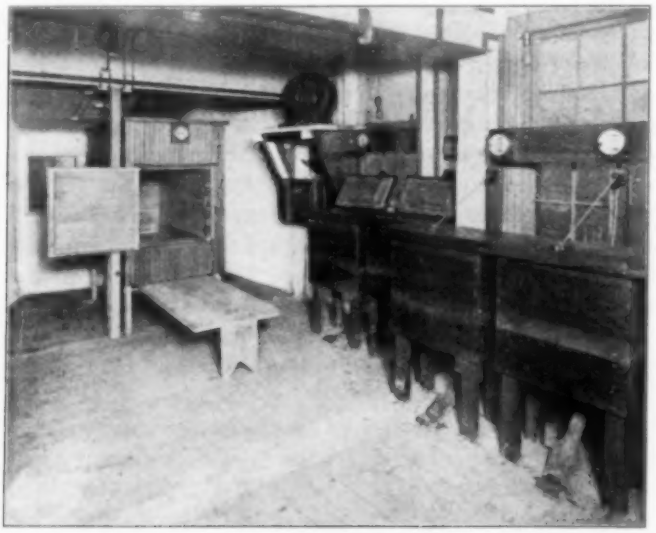
For some years past the problem of a satisfactory disposal of the superfluous animals has been one that seriously concerned the board of management, and led ultimately to the adoption of the apparatus now in use.

The electrical plant installed at the headquaters of the Animal Rescue League of Boston consists of one cage for dogs and four cages for cats. It is a plant that can be and is operated readily by one man, who, by this means, can destroy 200 cats or 100 dogs an hour. Two men, working together, can destroy 300 animals an hour, so that even this relatively small plant, if it were operated to its full capacity, would be equal to the demands of any of the largest animal shelters in the world.

From the first it became evident that on account of radical differences in temperament and disposition as well as of size, dogs and cats would require an entirely different type of apparatus. Dogs are used to wearing collars, and, if they have comparative freedom of movement in a large, well lighted and ventilated cage, they enter and remain in such an enclosure without protest. Cats, on the other hand, do not submit readily to the

collar and lead. If they can be placed comfortably in an open box, and lapse to unconsciousness the instant the cover is closed, they can be absolutely destroyed without any preliminary terror; and this is precisely what happens to them when they are put into the automatic electric cages.

A very clear idea of the two different types of cages may be obtained from the illustrations. The dog cage, standing on legs about eighteen inches high, occupies a floor space of two and one half feet wide by five feet long. The cage is large enough to receive any dog up to the largest St. Bernard or mastiff. The top of the cage which is about six feet from the floor, is of glass. A mirror placed over it at an angle of forty-five degrees gives a



Automatic Electric Cages at the Headquarters of the Animal Rescue League, Boston. Dog Cage on the left; four Cat Cages on the right; reversed rotary for generating current on bracket at right of Dog Cage.

good view of the interior. The inner cage, which is electrically insulated and so arranged that it cannot be touched by a person outside when the door is closed, has at the bottom a metal pan. From metal bars on either side of the inner cage depend strong spiral springs with snaphooks at the lower ends. One of these bars is connected through one of its metal supports into the secondary electrical circuit. The primary current is controlled by the closing and opening of the door by means of automatic contacts. When the door is open no current can enter the cage. When the door is closed, the current passes to a transformer at the back of the inner cage, and comes to the respective metallic connections at high potential. In operation, a flexible metal collar provided with suitable electrode points

is placed on the dog, the end of a spiral spring is hooked to the collar, and the dog is placed in the cage. The spring slides readily on the metal rod and gives the animal freedom of movement. The instant the door is shut, the animal gets the full force of the shock and lapses at once into unconsciousness.

Dog in Electric Cage. It has freedom of movement and no current is in the cage till the door is closed.

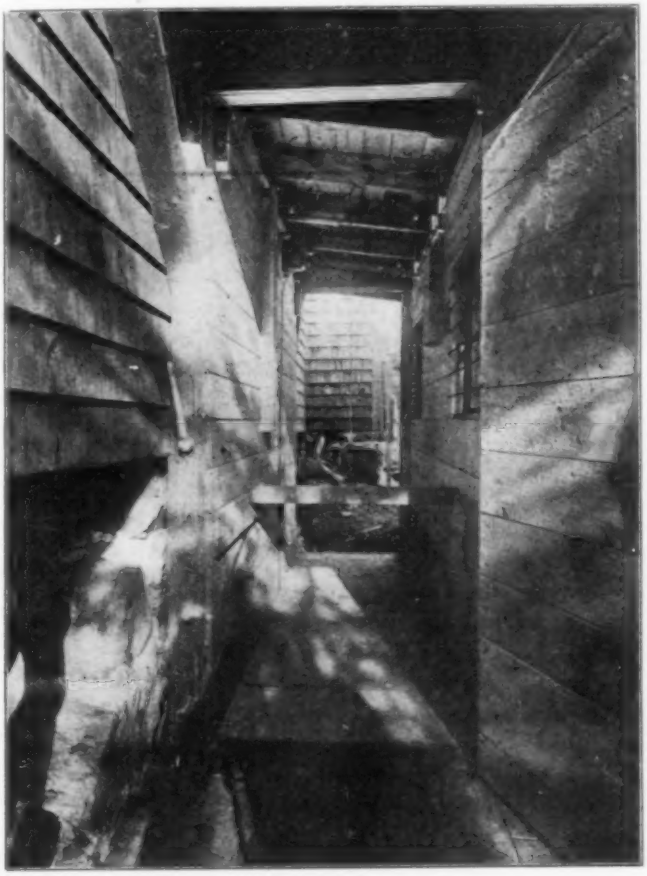
The cat cage, set on legs to bring it to a height convenient for the operator, occupies a floor space of about two feet square. Inside the cage, insulated from the outer box, is a box of slate with moisture-proof joints and having electrodes on the bottom, separated by an intervening space and an insulating strip. The electrodes extend up the ends of the box, and are

so arranged that they can be easily lifted for cleaning. As in the dog cage, the primary current is brought to the inside of the outer cat cage, to automatic contacts operated by the closing and opening of the cover. This cover, having an inside projection which falls over and a little within the inside box, is equipped with a cord, pulley, and treadle, so that the operator can lift it by foot pressure, and thus have both hands free to manage the

Electric Cage for Destroying Cats. Operator taking Cat from Cage after it has received the lethal shock.

animal. Taking a cat in both hands, he places it in the box in such a way that the two fore feet of the animal are on one electrode and the two hind feet on the other. In this position the cat is perfectly comfortable and has plenty of light and air. The instant the cover is closed, the electric circuit is completed. The primary current goes to the transformer on the inside of the outer cage, and the secondary current, at high potential, returns to the electrodes and passes through the body of the animal.

The time allowed for the destruction of life in the average cat is one minute, or twice the time given to the average dog. The difference may be due to the greater inherent vitality of the cat, to its organic resistance to the electric current, or, what is more probable, to differences in contact, owing to dryness of skin, fineness and density of fur, and so on. This



Interior of Electric Stall. A horse to be killed stands on a metal floor and electric connection is made by the chain hitch to the bridle ring.

element of time is apparently essential to death by the electric current, and experience would seem to indicate that there would be no material decrease in time if a much higher voltage or greater volume of current were provided. In no case, where measurements have been made, has the amount of electrical energy taken by the animal nearly approached the maximum available.

One very noteworthy feature of death by the automatic electric cage is the fact that there is absolutely nothing repulsive about it. The bodies come from the cages, relaxed and warm, and so perfectly peaceful in appearance that, if it were not for the widely opened eyes, they would seem asleep. The effect on the operator is very noticeable, especially if he has been used to other and less beneficient methods of slaughter. Instead of the gas chamber, the "shooting gallery" and the chloroform box, with all the accompanying horrors, we have a method of destruction that produces instantaneous unconsciousness, unaccompanied by any preliminary surprise, fear or pain. It comes as near as we can reasonably hope to attain to absolute euthanasia.

As to the cost of this work, where alternating current is commercially available it is so slight as to be almost nominal.

At the League, where it was necessary to install a "reversed rotary" to obtain an alternating current the approximate cost, including the losses of the electrical machinery, figures out less than one fifth of a cent for each animal destroyed, with the d. c. meter rate at ten cents a kilowatt hour. The efficiency of operation is, indeed, a continual source of astonishment to expert electricians and biologists. Those not familiar with electrical matters may be interested to know that the energy taken to kill the average animal is less than one half that required to operate a sixteen candle power lamp, and this only for a minute, or a fraction of a minute.

Equipped with a mechanism similar to that of the Automatic Electric Dog Cage, an electric stall for the humane destruction of horses has been constructed at the Pine Ridge Home of Rest for Horses at Dedham, Mass. The stall has a door at each end and two observation windows. A horse led into the stall stands on a metal plate and is held by a chain hitch to the bridle ring. With approximately the same current and voltage as are used in the dog cage, horses are killed from twelve to ninety seconds, the time apparently varying with the condition of the animal and its susceptibility to electric shock.

The apparatus has been examined and tested by many scientific and professional men and others interested in humane work and has received their unqualied approval. This apparatus is the invention of Mr. Huntington Smith, the managing director of the Animal Rescue League of Boston, Mass.

The Incineration of the Animal Bodies

The final disposition of this large number of animals received annually by the League was another problem that compelled attention. The directors were much in favor of the sanitary and scientific disposal by incineration within the premises if this could be done effectively and economically.

The problem proposed to the engineer called into consultation was to provide a furnace that would cremate an average of 600 to 800 pounds of animals in two hours time, and with a consumption of gas as fuel not to exceed 1,250 cubic feet per hour, without creating smoke or odors that could be regarded as a nuisance in a thickly settled part of the city.

To meet these conditions there was designed by the writer a crematory, or more properly a "destructor," 9 feet in length by 6 feet in width and 5½ feet in heigth placed in the room immediately below the electrical cages. The furnace is built of brick work throughout, the interior of highly refractory fire brick with exterior red brick walls, reinforced and supported by vertical and horizontal steel bands. There is one large charging door and lower door for removing ashes. The interior is divided into two chambers by a tranverse horizontal arched partition of fire-clay moulded brick blocks.

The upper chamber has a capacity for 600 to 800 pounds of bodies for one charge.

The lower and smaller division acts as a primary combustion chamber for the heat derived from three large specially designed gas burners placed at the rear end. These burners are connected to a header and this with a pipe line from the street main and meter, with valves for controlling the volume and a small motor and air compresser supply the air pressure to the burners.

Between the upper chamber and the chimney flue is a series of chequer work perforated fire brick partition walls which becomes highly heated and completes the combustion of the smoke and inflammable gases before they are allowed passage to the chimney.

The operation is conducted by first raising the temperature of the upper chamber and connecting brick work to 1,250 degrees and at once placing the charge through the side door upon the fire brick grates. The heat is then raised to the necessary destroying temperature, 1,500 to 1,900 degrees, and continued until the cremation is half completed, when the burners are then gradually cut off and the final incineration is by the contained and radiated heat of the interior.

The furnace went into use in October, 1910, and in the succeeding fifteen months destroyed upwards of 100 tons of animals with an expenditure of gas averaging from 2,500 to 2,800 cubic feet per day.

The rate of combustion and amount of gas required varies with the calorific values of the material consumed depending mainly upon the quantity of fatty matter contained. For instance one charge of 800 pounds was consumed using only half the power of one burner and in another case the gas was used only one half the usual time. In 6 months, February 1 to August 1, 1912, there was burned 110,300 pounds in 456 hours with 321,000 feet of gas.

This gives a gas consumption per pound of material burned of 2.91 cubic feet and the rate of combustion at 4.39 pounds per minute. The average of seven runs was 1,400 pounds burned at the rate of 3.69 pounds per minute with a gas consumption of 2.35 feet per pound of material destroyed.

In the ten months since the permanent plant was installed there have been destroyed 25,000 animal bodies in daily continuous use with no repairs and in an entirely sanitary and satisfactory manner.

All of the apparatus of electric cages is contained in a room 15 feet long and 8 feet wide. The destructor, motor and air compressor occupies about the same space on the floor below.

Taken as a whole this equipment for terminating the life of animals and the destruction of their bodies is the most sanitary, efficient and humane method in use in this country for providing for the disposal of useless animals.

It is decidedly worth the attention not only of managers of Humane Societies but of municipalities, where the problem, at least on its sanitary side is closely connected with the welfare of every civilized community.

HEALTH DEPARTMENT REPORTS AND NOTES.

TO STATE AND MUNICIPAL HEALTH OFFICERS.

This new division of the Journal is specially designed to be of use to active Health Officers of the countries represented in the American Public Health Association. It will be unable to serve its true function unless the Health Officers are willing to coöperate by sending to the Journal copies of their reports, bulletins, new ordinances and personal information which will be of general interest. Furthermore it would be distinctly desirable if communications on subjects of general interest are submitted for publication in this division of the Journal. The management will further welcome any suggestions from Health Officers for the improvement of this division. All communications should be addressed to Selskar M. Gunn, Managing Editor, American Journal of Public Health, 755 Boylston St., Boston, Mass.

REPORTS.

Clinton, Massachusetts.

The Board of Health of Clinton presents its report for the year ending January 31, 1913. The death-rate for the year 1912 was 14.53, the highest since 1910, a condition perhaps due to increase in population and the fact that the rate is based on the 1910 census. The birth-rate is not given. The report would be improved by the introduction of the international system of classification of deaths.

The work of the board is carried on by nine agents, which it appoints at salaries ranging from $200 to $900 per year, only two being over $500.

The report of work accomplished indicates that the various employees are doing thorough work and using up-to-date methods. Contagious diseases have been well taken care of and a threatened epidemic of smallpox was promptly headed off by a wholesale vaccination in which 6,000 vaccine points were used. An epidemic of measles attacked the city in December, 555 cases being reported in a single month.

Work along various popular lines of sanitation have been undertaken, including crusades against tuberculosis, the roller-towel, flies and mosquitoes. A city clean-up day has been inaugurated. The score-card system of dairy inspection is used and the scores are published with beneficial results.

North Yakima, Washington.

Dr. Thomas Tetreau, health officer of North Yakima, presents his report for 1912 in the annual report of the city. North Yakima has an estimated population of 16,500 and this report is the first since the adoption of the commission form of government. The Health Department believes in publicity and issues a monthly bulletin as well as additional educational pamphlets. It might be advisable to issue the yearly report as one number of the monthly bulletin, but it certainly does not suffer from comparison with the reports of the other departments and adds to the appearance of progress which the rest of the book presents.

The annual cost per capita of the Health Department is $1.20, or $1.33 if the work of meat inspection is included. The death-

rate for 1912 was 9.15 per thousand and the birth-rate 18.4. The mortality of infants under two years of age is 89 per thousand births. The international classification of deaths is used and is tabulated by months and ages. No deaths are reported from measles, scarlet fever, or whooping-cough, and the total from contagious diseases, including diarrhœa and enteritis, is thirty-six, of which twenty were due to tuberculosis of the lungs. The food inspector, bacteriologist and city nurse (who serves as superintendent of Associated Charities) are all women but present a record of work accomplished which many men in these positions fail to equal.

The whole report tells plainly of enterprise and hard work and the only improvement to be suggested is that it should be expanded and added to by reports of work other than the tables to which it is limited in its present form.

Pueblo, Colorado.

The annual statement of the city controller of Pueblo for 1912 contains a brief tabular report of the work of the board of health during that year. The expenditure for health work is about twenty-three cents per capita per annum. The death-rate is not given but appears to be 10.97 per thousand. The tables are inadequate and poorly chosen and classified throughout. For example, in the tabular statement of the causes of death, instead of using the Bertillon classification, a confused system is found, including modes as well as causes of death, overlapping and incomplete terms, and, incidentally, 15 per cent. of all terms used are misspelled. It is not even arranged alphabetically and gives no division of totals into age groups and monthly periods. Stillbirths are included among the deaths.

Scranton, Pennsylvania.

The annual report of the Bureau of Health of Scranton, Pa., for the year 1912 is fairly representative of the work that can be accomplished by an underpaid, undermanned Health Department. Its forty-eight pages epitomize rather than expand upon the work of the year. Obviously the report is designed to supply the layman with the conventional, routine information collected in the local office. With a population (estimated) of 134,500, the death-rate is 14 per thousand or .78 less than in 1911, and the birth-rate is 28.7 (exclusive of premature births which shortly proved fatal). Associated with the low death-rate is a death-rate from tuberculosis of 80.2 per 100,000 inhabitants, and 11.1 for typhoid, while for diarrhœa and enteritis under two years of age it was 145.7, and for violence 113.9. (The latter two rates are exclusive of non-resident deaths.)

The Bureau of Health is under the Department of Public Safety. The staff consists of the superintendent, a secretary, a bacteriologist and his assistant, a food inspector, an inspector of dairies and watersheds, a plumbing inspector, a fumigating officer and two sanitary officers. By no means full time is expected of all these men. Consequently the extent of the work reported by the food inspector, inspector of dairies and watersheds, bacteriologist, plumbing inspector and the summary of the sanitary work for the year is all the more creditable. Whether the city does not get more than it pays for with its totally insufficient appropriation of $11,000, or nine cents per capita, is somewhat of a question. The urgent request for another inspector of meats and other foods, and a plumbing inspector deserves an attentive ear, but far more important and valuable than these would be the establishment, as the superintendent, Doctor Keller, urges, of a hospital for the isolation and treatment of contagious diseases. Scranton, the center of a population of over 500,000, within a comparatively short radius, has no such hospital.

A welcome addition to this report is the publication of tables containing the number of deaths and the rate per 100,000 of the more common contagious diseases, cancer, violence and the birth and death-rates, since the year 1879. Splendid decreases are noticeable even in recent years in typhoid and scarlet fever. In connection with these tables, as with most of the others, one serious criticism must be made. Non-resident deaths are not included. Nor is it always entirely clear in other tables whether they are included or not. A similar criticism is called forth by the exclusion from the total births and the total deaths of premature births resulting in death. While the state law requiring death certificates on premature births after four months gestation seems severe, as long as other cities include premature births among their deaths, and since the Census Bureau at Washington includes them, this further raising of the death-rate should be courageously faced by Scranton.

As in most cities the weakest link in the sanitary chain is infant mortality. As yet the work along this line has been without marked results, although each year has seen some improvement in the milk supply. The work of voluntary organizations has been sporadic.

The unusually high death-rate from violence, 113.9 per 100,000, finds some explanation in the dangers of the coal mines, one-third of the above deaths occurring from that source. More obscurely, we imagine, lies the explanation of the death-rate from burns which is so peculiarly high.

While the 1912 report makes no mention of it, it will be remembered that Scranton was one of the first cities to enjoy a preliminary survey by the Russell-Sage Foundation. The effect of this survey of last spring will be watched with interest and in the 1913 report will find, we trust, full consideration.

Williamsport, Pennsylvania.

Williamsport, a city of 35,000 population, claims to spend only fifteen cents per capita per annum for its board of health, which employs nine agents in its work. No tabulated financial statement is presented in the report.

An alphabetical system is used for the classification of deaths, which is about as satisfactory as this method ever is, but the total deaths and the death-rate ("about 13 per thousand, deducting stillbirths and accidents") are found only after diligent search in another section of the report. The chief cause of death, it is interesting to note, is pneumonia with a record of seventy for the year. Contagious diseases appear to be well controlled with the exception of measles which has a record of 531 cases in three months. The tabular record of contagious disease might better be condensed from the five pages which it now occupies to a single page.

Regular medical inspection of schools has proved of value in raising the general sanitary condition of the city. Dairies are inspected and graded by an arbitrary system without reference to any score card, two thirds being placed in the first class which includes all those where conditions are good for the production of wholesome milk. The number of nuisances has been reduced by having a general cleaning by the street department during the month of May, with free removal of refuse.

The Newburgh Survey.

The report of the limited investigations of social conditions in Newburgh, New York, has recently been issued by the Department of Surveys and Exhibits of the Russell Sage Foundation. It contains 104 pages bound in paper cover and may be obtained from the office of the Foundation at 128 East Twenty-Second Street, New York City, for fifteen cents per copy. It is illustrated with numerous half-tone engravings of scenes in

Newburgh and with reproductions of display charts which graphically point out present conditions and how they may be improved.

The report comprises investigations of public schools, public health, housing, delinquency, public library, recreation, charities, industrial conditions and municipal administration. While all of these reports are well prepared and instructive those on "Housing" by Miss Amy Woods, on "Industrial Conditions" by Edward F. Brown and Zenas L. Potter, and on "Public Health" by Franz Schneider, Jr., will be of particular interest to the readers of this magazine.

Mr. Schneider's article on public health is excellent and should be read by all who are interested in municipal health work since it has been prepared with a view to general improvement in conditions which may apply to any city even though it is directed at Newburgh, which appears to present a fertile field for the introduction of such improvement. The most modern methods in use over the country are put forward as models and while the article is unfortunately limited in extent it might serve as a text-book or, at least be of great value as a reference work for many health officers.

At the time of the survey Newburgh was a city of 31,242 inhabitants, but spending less than twelve cents per capita for their health. The control of health work was entrusted to a board of seven members, which employs a health officer who devotes only one hour a day to the work. In this time he does creditable work, but recognizes the fact that little constructive activity is possible under such an arrangement. As might be expected modern methods and lines of activity are almost wholly lacking. Sanitary supervision of the city's water supply, food supply, and housing conditions are lacking. Communicable diseases are inadequately controlled as a result of lack of facilities for laboratory diagnosis and hospitalization, and the absence of medical inspection of schools. As a result of all these conditions vital statistics are deficient, the typhoid rate is high, infant mortality is above normal and general sanitary conditions are in a disgusting if not a positively dangerous condition.

Mr. Schneider closes with the following summary of recommendations for improving upon the opportunity offered by the natural health assets of the city:

"The situation calls for a thorough-going re-organization. A full-time health officer, endowed with proper authority and responsibility, is indicated; and additional assistance in the form of nurses or inspectors should be provided to permit of new and important work in tuberculosis, infant hygiene, the control of communicable diseases, and various sanitary inspections—such as of housing, privy vaults, and the like. The milk, water, and food supplies—now neglected, should receive reasonable supervision, both from the standpoint of inspection and of laboratory examination. A health department clinic and dispensary, which should be of great help in eliminating unrecognized and neglected sources of infection in the city, and in the health department's work against infant mortality and communicable diseases, is also earnestly suggested. Finally, a thorough investigation of the typhoid situation should certainly be instituted. These steps, if taken, should materially increase the efficiency of the present work and secure to the city an up-to-date and reasonably complete health program.

"It must be emphasized that these recommendations embody the minimum requirements for a progressive city, and it is fortunate that to secure them, and so place Newburgh among the more thoroughly civilized cities of her class, will require the expenditure but of a few thousand dollars. The statement is now freely made by authorities that, within limits, public health is purchasable. The opportunity to buy now confronts Newburgh in practically its entirety."

DEPARTMENT NOTES.

Low Temperature Pasteurization.

In order to determine the best way of pasteurizing milk so as to kill the disease germs and yet not give the milk a cooked flavor or lesson its nutritive value, the Department of Agriculture, through its dairy division, has been conducting a series of experiments, treating milk at different temperatures and for different lengths of time. According to the report on these experiments in *Bulletin 166 of the Bureau of Animal Industry*, when milk is pasteurized at 145° F. for thirty minutes the chemical changes are so slight that it is unlikely that the protein (muscle-building element) or the phosphates of lime and magnesia are rendered less digestible than they are in raw milk.

Moreover, from a bacteriological standpoint, pasteurizing at low temperatures is found to be more satisfactory than pasteurizing at high temperatures. According to *Bulletin 126* and *Bulletin 161*, where low temperatures are used, the majority of bacteria that survive are lactic acid organisms which play an important part in the normal souring of milk. When milk is efficiently pasteurized at high temperatures the bacteria which survive are largely of the putrefactive kinds, and milk so treated if kept for any length of time has a tendency to rot instead of sour. From the standpoint of economy, the technologist of the dairy division finds that pasteurizing at low temperatures calls for less heat. It is found that it takes about 23½ per cent. less heat to raise milk to the temperature of 145° F. than to a temperature of 165° F. A similar gain is a saving of the ice needed, because it will require 23½ per cent. more refrigeration to cool milk to the shipping point when it is pasteurized at the higher temperature. The department, therefore, recommends that, "When market milk is pasteurized it should be heated to about 145° F., and held at that temperature for thirty minutes."

Schoolroom Health Officers.

The committee on janitor service of the National Education Association's Department of Science Instruction has recently published a summary of its recommendations. The report points out the fact that janitors are often as well or better paid than school teachers but are usually not prepared or tested before appointment and are especially lacking in a knowledge of sanitation. Therefore, it is urged that, in order to get facts preparatory to the standardization and improvement of janitor service, the coöperation of the students be enlisted.

It is suggested that in a room the children be appointed health officers with a length of service such that each child has a period of service at least once a year. If found advisable credit may be given for this in physiology, hygiene, or biology. The observations which can be made will vary with the age of the children and range from hourly reading and plotting of temperatures, humidity and air currents to determinations of dust and bacteria in the air and photometric determination of illumination from windows. The results of these observations may be charted on the blackboard or reports may be made to teacher or principal who alone are allowed to "interfere with the janitor."

Wherever possible the pupil is expected to regulate abnormal conditions as in the case of heating devices, ventilators, open windows and humidifiers. In elementary grades the children may assist in keeping the room free from dust by wiping surfaces with a clean, preferably moist, cloth. Health officers should report the sweeping of rooms or corridors while in use by pupils or teachers and the cleanliness of washbowls, water-closets and windows. It will often be found advisable to introduce health officers from the older grades into rooms where the children are too young to do the necessary work.

The plans suggested will probably meet with opposition from the school teacher who pictures the distraction of attention consequent on having a classmate rushing about reading thermometers, whirling psychrometers and aspirating air through a tube of sugar, but the novelty will soon wear

off and there is little doubt but that a student health officer is a much greater benefit to his classmates than a "monitor of the gold-fish bowl."

New French Method of Garbage Collection.

"Paris has long fought against the method of garbage collection used in that city. The carts are of an old type; they are slow; much of the refuse collected falls back into the streets; the odors are unpleasant, and the hours of collection inconvenient. A new system is about to be installed in which all these disadvantages are remedied. The new wagons are electric vehicles. Forty-one are to be put in commission immediately, and will make three trips each between the hours of 6 p. m. and 7 a. m., after which hours it is expected there will be no garbage cans on the sidewalks. This will enable the flushing of the streets to be carried on after the collection of the garbage and not during it, as now."

The American City, September, 1913.

Milk Infection from Return Cases of Scarlet Fever.

"The association of milk infection with return cases of scarlet fever has not been hitherto recorded, and the following outbreak, which was reported to the Glasgow committee on health by Dr. A. K. Chalmers M. O. H., affords evidence of the care which should be exercised with patients discharged from hospital when discharge from the eyes or nose is present. The outbreak occurred in November last.

"Twelve cases in all occurred, affecting eleven households. An interval of sixteen and thirteen days respectively separated the two earlier cases from the others, the dates of sickening being November 2, 5, 18, 23, and 26 (one case each), November 20 (three cases), and November 21 (four cases).

"All the employees at the dairy, of which these families were customers, were medically examined without furnishing a history or showing any symptoms suggesting scarlet fever, but when the farm from which the milk supply of the dairy was obtained was visited, and the members of the household examined, it was found that two of the farmer's children had been dismissed from one of the county fever hospitals, one on October 26, and another on November 16, and that the former was suffering from an acrid nasal discharge, so frequently associated with return cases of the disease, while the latter bore evidence of having recently had a similar discharge. Doctor Chalmers writes:

" 'It has long been recognized that children dismissed from hospital apparently recovered from these complications are liable to recurrence thereof, and thereby occasionally to transmit infection to other members of the family on their return home, but there is no case recorded hitherto, I believe, where milk would appear to have become the carrier of infection thus acquired, and the explanation in the present instance would appear to be that the mother attended to the child with the discharge, and was also engaged in milking.' The children were at once removed from the farm, the premises disinfected, and no further cases occurred."

The Medical Officer, October 18, 1913.

Anti-Typhoid Vaccination for Children.

"The use of anti-typhoid vaccination among children has as yet received little attention, perhaps because we do not ordinarily think of typhoid fever as a disease of childhood. Yet, according to no less an authority than Osler, this is a disease of youth and early adult life. Out of 1,500 cases treated in the Johns Hopkins Hospital, 231 were under fifteen years of age, and 255 were between the ages of fifteen and twenty.

"In a recent issue of the *Journal of the American Medical Association*, Major Russell of the Army Medical Corps discusses the inoculation of 359 children, between the ages of two and sixteen years who have been vaccinated by fifty different physicians in many parts of the United States. No harmful effects have been reported in any of the 359 children and, so far as known, none has contracted typhoid fever, although some of the vaccinations were made over three

years ago. Major Russell regards it as a particularly valuable method in the case of children and young people leaving home for summer vacations, school, college, etc.

"The importance of checking typhoid among the young is shown by the fact that in the registration area of the United States there were in 1909, the last year for which complete mortality statistics are available, a total of 3,366 deaths from typhoid fever in patients under twenty years of age, out of a total of 10,722 of all ages, or almost one-third of all deaths from the disease. They were distributed according to ages as follows: under two years, 97; under three years, 139; under four years, 132; under five years, 110; five to nine years, 647; ten to nineteen years, 2,174. A very large proportion of these deaths could, without question, be prevented by the more frequent use of anti-typhoid vaccine."

The Survey, August 30, 1913.

Troglodyte Sailors.

"Dr. Herbert Williams, medical officer of health for the Port of London, has again drawn attention to the fact that the conditions under which seamen live on board vessels are extremely favourable to the spread of infection and the development of disease. He continues: 'The occupants of the seamen's quarters on board many ships may be described as "troglodytes," for indeed many of these places are very similar to caves, constructed of air-tight materials, dark, overcrowded in a hygienic sense, and ventilated (?) by an iron pipe which is generally blocked up, thus only allowing the fresh air to enter by the door.' He quotes the following example, which was met with during last year, as indicating the possible danger which may arise from persons on board suffering from pulmonary tuberculosis: 'The chief baker on a steamer carrying a number of passengers was working on board the ship from April 29, 1912, until November 2, 1912, when he was found to be suffering from pulmonary tuberculosis and was put off duty.' Doctor Williams thinks that comment on this case is needless—the objection, if not the danger, must be realized by everyone."

The Medical Officer, August 2, 1913.

"Missed" Cases.

"The mildest cases of either diphtheria or scarlet fever are as dangerous for well children to be associated with as are those of the most malignant type, and the most dangerous of all is what is called the unrecognized case of either of the diseases mentioned. It is well known that from the mildest cases of either diphtheria or scarlet fever the most malignant form may be, and often is, contracted. Many times people will insist upon the early termination of quarantine for the reason, as they put it, 'The child was hardly sick at all.' For the same reason, too, they will think that the disease 'could not be catching.' This is a a serious mistake, as the child with a light attack is just as dangerous, as a means of spreading the contagion, as is the child that has the disease in its worst form.

"Here is a case that illustrates what we are trying to make clear: A young married man with a wife and little child complained of not feeling well for nearly two weeks, but despite this fact continued at his work. At the end of this time his wife was taken with scarlet fever in its worst form and a few days later, after her removal to the hospital, the baby was stricken with the same disease. Within ten days after their admission to the hospital both the mother and baby died. An examination of the husband, made at the time his wife was taken sick, showed that he had had scarlet fever in a mild form and was still suffering from it. The only trouble was that it was so mild that it was not recognized as being scarlet fever, but it cost him the lives of his entire family. Mild cases spread more contagion than do the severe ones."

Press Service of Chicago, Department of Health, September, 1913.

Control of Vice.

John Haynes Holmes of the Church of the Messiah, New York City, suggests in an article in *The Survey* of September 27, the

following measures which shall serve as what he terms "a flank attack on vice":

"1. Adopt the 'Little Tin Plate' ordinance, already enacted at Portland, Ore., and now pending before the aldermen in New York, which provides for the posting of the name and address of the owner of a building on a conspicuous part of his property. Houses of prostitution will be few and far between when the name of the owner is lifted as high as Haman for the passerby to read.

"2. Enact a law, making it impossible for the owner of a house of prostitution to collect insurance upon his property. I am informed—I know not how accurately—that such a measure is in force in Wyoming, with excellent results.

"3. Enact a law, providing that the property in a house of prostitution, like the paraphernalia in a gambling house, shall be subject to public confiscation, and may be destroyed on order from the court.

"4. Enact a law, empowering a board of health, either state or local, after due investigation, to declare a house of prostitution a place of contagious disease, and to order the same closed and abandoned. This is one of the excellent suggestions of the Chicago Vice Commission.

"5. Enact a law, declaring a house of prostitution to be a public nuisance, and empowering any citizen to institute summary proceedings for the abolition of the nuisance.

"6. Provide at municipal expense, decent forms of amusement to supplant low dance-halls, theaters, etc., which now debase the morals of the people for private profit. This was one of the original recommendations of the New York Committee of Fifteen.

"7. Above all, by one sweeping attack around the enemy's flank upon his base of supplies, guarantee to every working girl an ample living wage, short hours, and decent conditions of labor."

Milk and Cats.

"The question of sanitation in the home may be studied from many sides. We often find causes of diseases where we least expect to. In any case of contagious disease, the Health Department endeavors to find the true cause of such disease and thereby prevent further infection. In many instances, it is next to impossible to get the least clue as to what caused the disease in the first place.

"One condition which may be the cause of contagion is the contamination of milk bottles by cats and dogs. Usually, a small quantity of milk is left on the top of the cap on the bottle. This is consumed by the wandering feline as a rare delicacy. Cats are known to be very susceptible to diphtheria and, consequently, may easily carry the germs of that disease and, no doubt, may be looked upon with suspicion when no other cause of the disease can be discovered.

"The public, to protect itself, should give the matter consideration. Milk bottles, when left by the milkman, should be placed in such manner that they are out of reach of cats or dogs. This can easily be done by providing a shelf, or still better, a box-like compartment which keeps it both safe and cool until taken into the house.

"Many modern houses have these milk receiving compartments built into the wall. However, if they are not supplied in the house you occupy, they can readily be provided. Any reasonably well made box will serve the purpose. It is advisable to have this box placed in a cool and sheltered spot during the summer time; in a reasonably warm spot during the winter months. Milk always deteriorates under the sun's rays and heat and equally deteriorates if frozen. So both conditions should be guarded against as well as the contamination that may result from cats, dogs or other animals' contact."

The Milwaukee Healthologist, September, 1913.

Ozone.

"The use of ozone for purposes of bacterial destruction has been advocated in the sterilization of water, the purification of the air in rooms and the control of infections in general. At the time of testing the methods for the purification of water to be used in the public schools of Buffalo it was found that devices relying upon ozone as the purifying agent were not successful. Recently, Jordan & Carlson, and

also Sawyer, Beckwith and Skolfield have published their results, which confirm the opinions of Hill, Flack, Konrich, Schwarz and others, that ozone generated in rooms by electrical devices produces an irritation of the respiratory tract without being of any value as a bactericide in the air. They condemn its use in schools, offices and other places where persons are confined, and claim in addition that faulty ventilation cannot be detected.

"For these reasons the use of ozone either for water purifying or the attempt of room disinfection does not seem applicable."

Buffalo Sanitary Bulletin, September 30, 1913.

Swat the Cockroach.

"Among the household pests that are the bane of all good housewives, the cockroach ranks along with mosquitoes and the much dreaded bedbug. If anything tends to destroy the good temper and peace of mind of the cleanly and order-loving housewife, it is to have her kitchen swarming with cockroaches. Until recently, however, the cockroach has not been thought of as a possible carrier of disease. But in the light of experiments conducted in the laboratory of parisitology in the University of California, it appears that if the house fly carries the germs of disease, the cockroach is scarcely less dangerous in the same way and transmits bacteria in a similar manner; that is, by collecting the germ-laden filth on its feet and mouth parts and by feeding on filth and discharging this when feeding on human food. It is shown that the cockroach invades places where contaminating material, such as sputum or excrement, is found and that its food habits are such as to afford ample opportunity for its contaminating the food of man."

Chicago Department of Health, *Press Service*, October, 1913.

Public Health in North Carolina.

"Last Monday at the regular session of the Board of County Commissioners, Orange County made an appropriation of $250 for the purpose of coöperating with the State Board of Health in establishing a public health and hookworm campaign in that country. Randolph and Davidson counties recently made similar appropriations for the same purpose. This makes ninety-nine of the one hundred counties in North Carolina that have shown a sincere interest in the welfare of their people. Human lives and human suffering have appealed to the comsioners of these counties above dollars and cents. The value of good citizenship has been rated above live stock, in contradistinction to the custom existing in North Carolina in the days gone by. This is a most remarkable situation in the health work of our state. But for the failure of the Ashe County board to take favorable action it could have been reported that every county in North Carolina is interested in its health conditions, and had coöperated with the State Board of Health, and provided funds to better the health and sanitary conditions of its people.

"No other state in the Union has reported such a marvelous awakening of its people, and it is to be hoped that at the next meeting of the Board of Commissioners of Ashe County they will reconsider their decision and thus make the counties of North Carolina unanimous in their action and attention to health and sanitary matters.

"Dr. C. L. Pridgen of the Hookworm Commission of the State Board of Health is hoping to report before long that an active health campaign has been conducted in every county in the state. This will give North Carolina her usual place as the first of all the states of the Union to accomplish this."

N. C. State Board of Health, *Press Service*, September 15, 1913.

Cream Grading.

"At a meeting of the board of health of the Department of Health, held August 26, 1913, the following resolution was adopted:

"Resolved, That the following rules and regulations relating to the sale of cream in the City of New York be and the same are hereby adopted to take effect November 1, 1913:

1. *Grade A Cream.*

(a) Grade A Cream (Raw).

"Definition—Grade A Cream (Raw) is cream made from either Grade A Guaranteed Milk, Grade A Certified Milk or Grade A Inspected Milk (Raw).

"1. The cream shall be delivered to the consumer within 48 hours after milking.

"2. The cream shall not contain more than an average of 100,000 bacteria per c.c. when delivered to the consumer or at any time prior thereto.

(b) Grade A Cream (Pasteurized).

"Definition—Grade A Cream (Pasteurized) is cream which is made from any raw milk conforming to the requirements of Grade A, and which has been pasteurized.

"1. The pasteurization of cream shall take place within 36 hours after the process of separation.

"2. No cream shall be pasteurized more than once.

"3. The cream shall be delivered to the consumer within 36 hours after the completion of the process of pasteurization.

"4. The cream shall not contain more than an average of 100,000 bacteria per c.c. when delivered to the consumer or at any time after pasteurization and prior to such delivery.

"5. All containers in which pasteurized cream is delivered to the consumer shall be plainly labeled Pasteurized. Labels must also bear the date and hours between which pasteurization was performed, the place of pasteurization, and the name of the person, firm or corporation performing the pasteurization.

General Regulations for Grade A Cream.

"1. Unless otherwise specified in the permit, the cream shall be delivered to the consumer only in bottles.

"2. The caps of all bottles containing Grade A Cream shall be white and shall bear the term Grade A in black letters of large type, and the words of the subdivision to which the cream in the said bottle shall conform.

2. *Grade B Cream.*

(a) Grade B Cream (Raw).

"Definition—Grade B Cream (Raw) is cream which is made from Grade B Selected Milk (Raw).

"1. The cream shall not contain an excessive number of bacteria when delivered to the consumer or at any time prior thereto.

(b) Grade B Cream (Pasteurized).

"Definition—Grade B Cream (Pasteurized) is cream which is made from pasteurized milk or from Grade B raw milk and pasteurized.

"1. No cream shall be pasteurized more than once.

"2. No cream containing an excessive number of bacteria shall be pasteurized

"3. The cream shall not contain an excessive number of bacteria when delivered to the consumer or at any time after pasteurization and prior to such delivery.

"4. All containers in which pasteurized cream is delivered to the consumer shall be plainly labeled Pasteurized, and shall give the name of the person, firm or corporation performing the pasteurization.

General Regulations for Grade B Cream.

"1. Caps of bottles containing Grade B cream shall be white and marked "Grade B" in bright green letters, in large type, together with the words of the subdivision to which the quality of the cream in the said bottles conforms.

"2. Cans containing Grade B Cream shall have a tag affixed to each can with the term Grade B in large type, and the words of the subdivision to which the quality of the cream in the said can conforms."

Weekly Bulletin of the New York City Department of Health, September 13, 1913.

Health Bulletin Ethics.

"We feel highly complimented because the Kansas City, Mo, Health Department reproduced a greater portion of our May *Bulletin* in their last issue, much of which was original matter, but sorry to call their

attention to the fact that they have not extended us the courtesy of giving credit to its source of production. This is a matter that should be given more careful consideration, and, as Dr. St. Clair Drake, editor of the *Chicago Health Bulletin* put it, a very serious deficiency of many of our American health bulletin editors, and has led Chicago and others to copyright their bulletin issues against this violation of ethics and wholesale thievery. None of us have any objection to the reproduction of any of our bulletin matter, if proper credit be given."

Bulletin of the Nebraska City Department of Health, June, 1913.

"Canned" Health Lectures.

"Here is one way in which the State Board of Health can help you in your school, church, and community work. We have just secured two sets of lantern slides, with lectures already written out to accompany them. One of the lectures is on tuberculosis and is well adapted for any mixed audience, while the other lecture is on the general subject of health, the teeth, voice, hearing, and sight. It is especially adapted for schools, and for work on the medical inspection of school children.

"Any one can 'deliver' or read one of these stock lectures while some one else operates the slides in any ordinary stereopticon lantern.

"The State Board of Health offers to loan these slides and lectures free of charge to any school, church, club, organization, or public-spirited citizen who will agree to give a lecture from them provided they pay the express charges to their town. Then they may hold the slides and lecture until we send them an order requesting that they be shipped to some one else.

"Besides the slides and lectures, this board will also send you special bulletins to help you get posted on the subject on which you expect to lecture, and a limited quantity of various kinds of public health leaflets which may be distributed among the audience after the lecture.

"Here is a golden opportunity for any one at all interested in giving his club, church, or community an entertaining and instructive lecture. And if the lecturer wants to add more religion to his lecture, let him draw lessons from the life of the Great Physician, or let him teach modern sanitation from the Book of Deuteronomy.

"Doctors usually make excellent people to deliver such lectures. However, on account of the delicacy of medical ethics and on account of the difficulty in getting a good audience to an ordinary lecture, doctors thus far have not, as a rule, volunteered to give health lectures as freely as they might. But if some church, school, or public-spirited citizen will invite a doctor to give one of these illustrated lectures there will be little danger of his not accepting the invitation. Try it once.

"To secure these slides and lectures, write the State Board of Health, Raleigh. Do not announce the date for a lecture until you find out when you can get the slides."

N. C. State Board of Health Bulletin, September, 1913.

Milk Bottles and Typhoid.

"When a case of typhoid fever occurs in Asheville, the dairyman delivering milk to the afflicted family is immediately notified of the fact. That is usually enough to make the dairyman feel that to some extent his dairy is charged up with the case, until it is proven that no further cases occur on his route or that the first case was due to something else.

"Furthermore, the dairyman is not allowed to remove milk bottles from the premises of the sick person until the bottles have been sterilized by the health department. This is a very wise provision, because typhoid germs grow very rapidly in milk, and if the milk bottle should become accidentally contaminated with typhoid germs in the typhoid-stricken home the dairyman might contaminate his other bottles and cans in the course of ordinary washing and spread the disease to the rest of his customers. This is a very good precaution. What is the policy of your town in this matter?"

N. C. State Board of Health Bulletin, September, 1913.

PUBLIC HEALTH NOTES.

Campaign against Anti-Vaccinationists.

"On the bill-boards of a suburb of Berlin there was recently posted a large placard with the title Vaccination, Disease, Death, which made a propaganda against vaccination and finally recommended the procuring of a pamphlet which had the title, 'How Shall I Conduct Myself with Reference to the Demand for Vaccination?' The committee against quackery of the Berlin Aerztekammer (Medical Chamber) sent a communication to the communal authorities in which attention was directed to the very objectionable contents of the placard, and especially to the fact that by this placard and the pamphlet advertised in it the public was directly incited to disobedience to an imperial law. The communal authorities were requested to take action for removing the placard from the public placard columns. The town council immediately complied with this request and in a public statement asserted that the entire placard was suited to produce false ideas in the public mind."

Berlin Letter, Journal of the A. M. A., August 16, 1913.

Chicago's Clay-Hole Proposition for Garbage Disposal.

"Forced by foolish, bickering procrastination to dump the garbage of Chicago in clay holes because of the expiration of the contract with the Chicago Reduction Company on September 30, and because no preparations had been made to take over the service, Chicago presents a sorry spectacle of inefficient business management, all the more noticeable because of the very size of the problem.

"Three appraisers, Col. Henry A. Allen, for the city; Mr. Harold Almert, for the reduction company, and Mr. Leonard Metcalf, selected by the two first-mentioned appraisers, failed to make a unanimous appraisal principally because Colonel Allen did not consider 'going value' as an asset. His figure was $208,582, while that of the other two engineers was $492,500. The city refused to accept anything but a unanimous report, and when the time expired the reduction company quit taking garbage, with the result that since September 30 no collections have been made. At this season 600 tons per day are collected. On October 6 the City Council passed an ordinance renting a 32-acre clay hole, now used for rubbish dumping, instead of buying it, as authorized at a meeting October 1. A temporary handling plant is being thrown together and from experiments conducted by Dr. George B. Young, health commissioner, it is believed the garbage can be disposed of in a safe and inoffensive manner by giving it chemical treatment and subsequently covering it with rubbish. Only the sight will be filled by this method in a year and could then be converted into a park. Dr. Young estimates that the plant will cost $30,000; material for use up to January 1, $15,000; labor, $15,000, and incidentals, $15,000. The city has been paying the reduction company less than $50,000 per year.

"During the same council meeting at which the clay-hole proposition was put through the offer of the Chicago Reduction Company to sell its plant for $383,000 (more than $100,000 less than was asked a week previous) was rejected. Dr. J. M. Hirsh offered to pay the city 10 cents per ton for the garbage and have a plant ready in thirty days. His proposition was referred to the finance committee."

Engineering Record. October 11, 1913.

Would Use Discarded Battleships for Sanatoria.

"Rather than continue the present practice of 'scrapping' or using as targets discarded battleships and cruisers, Dr. S. Adolphus Knopf of New York, suggests in a resolution adopted by the Fourth International Congress on School Hygiene, that these vessels be used as sanatoria for tuberculosis patients. Dr. Knopf would have the government turn over to whatever states could use them, any

useless vessels, which may be adapted for sanatoria, open air schools, etc. He argues that while the cost of remodelling these ships would in some cases involve considerable expense, the necessary repairs would not cost as much as the erection of a sanatorium of equal capacity, and besides, in most cases, the difficulties in finding a suitable site would be obviated. In justice to those states, which by reason of their location, cannot make use of discarded battleships, Dr. Knopf suggests that a nominal sum should be paid for these vessels by the states which use them, this money in turn to be divided proportionately among the inland states for the establishment and equipment of open air schools, preventoria, sanatoria, or hospitals for consumptives. By such a policy, the greatest possible good for the greatest number of American citizens afflicted with tuberculosis will be attained. Dr. Knopf's ideas suggest the plan proposed by the Southwestern Tuberculosis Conference for the use of the federal government of abandoned forts in the Southwest for tuberculosis sanatoria. The political and constitutional objections raised against this plan at Washington seemed to be insuperable. The full text of the resolution as unanimously adopted by the International Congress on School Hygiene follows:

"*Whereas*, Nearly a million tuberculous children, or children strongly predisposed to tuberculosis, are attending our public schools, and there is hardly accommodation for 1,500 to receive instruction in the open air; and

"*Whereas*, The Congress is convinced that the open air school is one of the most powerful agents in the prevention and cure of tuberculosis in childhood, and it has been furthermore demonstrated that nearly all climatic conditions, providing the air is dust-free, lend themselves to the prevention of tuberculosis in the predisposed and the cure of the afflicted; and

"*Whereas*, Statistics show that there are not nearly enough hospital and sanatorium accommodations for adults and children afflicted with pulmonary tuberculosis or children suffering with tuberculosis joint or bone diseases; and

"*Whereas*, It has been demonstrated in New York and other cities that discarded vessels lend themselves admirably to transformation into all-year-around hospitals and sanatoria for consumptive adults, sanatoria for children afflicted with joint and other types of tuberculosis, and into open air schools for tuberculosis, anaemic, and nervous children;

"*Resolved*, That the Fourth International Congress on School Hygiene petition the United States government to place at the disposal of the various States of the Union as many of the discarded battleships and cruisers as possible, to be anchored according to their size in rivers or at the seashore and to be utilized by the respective communities for open air schools, preventoria, sanatorium schools for children, or hospital-sanatoria for adults. Be it further

"*Resolved*, That the Congress expresses its appreciation to the Italian government of the example it has given by consecrating three of its discarded men of war to the combat of tuberculosis. Be it further

"*Resolved*, That this Congress expresses the sincere wish that other governments may follow the example of Italy; and be it finally

"*Resolved*, That copies of these resolutions be presented to the American and other governments represented at this Congress."

Journal of the Outdoor Life. October, 1913.

Paper Milk Vessels.

"The hygiene advantages of papier mache milk vessels are strongly urged in a note by Mr. James S. Dunn, chief sanitary inspector for Kimberley, contributed to the 'Official Municipal Year Book of South Africa.' Mr. Dunn writes: 'Paper bottles have everything in their favour. They are filled at the farm while the milk is fresh and before contamination from the many extraneous sources. They are only used once and never refilled. Each purchaser is, therefore, assured of an original bottle of clean, wholesome milk providing all the precautions, applicable to the proper production of milk have been compiled with. The dealer also profits. He pays freight on the original car-

riage only and is relieved from the necessity of returning the empties.' Mr. Dunn adds that the collection of bottles, return freight on the empties, breakage, and bottles lost through various reasons, constitute a big item, while the cost of new paper bottles is very small in comparison."

The Medical Officer. October 4, 1913.

Public Health in Alaska.

"In the 60,000 square miles of Alaska there were in 1910 about 65,000 inhabitants, a little over one to the square mile. A sanitary survey of this population has just been completed by Dr. Krulish of the Federal Public Health Service, who traveled some 7,000 miles in Alaska during the course of his inquiries.

"Few Americans realize the size and importance of '' '' skan peninsula and its wonderful resources as yet undeveloped. Of the 65,000 population, 25,000, are natives (including Indians and Esquimaux) and only 30,000 are full-blooded whites.

"The white people of Alaska are on the whole healthy, and they give rather little attention to the administration of health laws, apparently because they are too well to bother about it, and because they believe in the 'superlative healthfulness' of the climate. The native population, however, are afflicted with many ailments, which are chiefly the result of their unhygienic living and the lack of facilities for the treatment and isolation of the infected. Tuberculosis, eye affections, and venereal diseases are the most important. The native population had decreased 14 per cent. between 1900 and 1910. About 15 per cent. of the native persons examined had tuberculosis—few of these in an active stage.

"The average native home has but one room, and the sanitary arrangements are primitive in the extreme. On the seacoast, garbage and rubbish are thrown into the sea; while in settlements located on rivers, they are thrown into the rivers. During the winter months all refuse is allowed to accumulate, and in the spring, if the village school-teacher can force the natives to bestir themselves, it is cleaned up and somehow disposed of. Says Dr. Krulish: 'It is in the crowded, unventilated homes, where all eat out of the same dish, drink from the same teapot spout, use the same towel, and expectorate on the floor, that the principal danger of contagion exists and that tuberculosis and trachoma are most frequently contracted.'

"The Federal Government, which has the territory of Alaska under its control, has endeavored to improve health conditions through the United States Public Health Service, and also by enlisting the aid of the school-teachers. They have been reporting monthly, births and deaths, although at present these reports extend to less than a third of the native population. The school-teacher is also called upon to initiate many local improvements.

"As the result of a survey of the towns and villages of Alaska, facts were gathered showing the existing health ordinances. All towns provided for the appointment of a health officer, for the disposal of garbage and sewage, the abatement of nuisances, and the isolation of contagious diseases; but, on the other hand, there is no community in Alaska which has an ordinance relating to the disposal of bodies, or for the destruction of flies, or for compulsory vaccination. How long will Alaska continue to depend only upon its climate?"

Medical Review of Reviews. August 19, 1913.

An Index of Refinement.

"True civilization and refinement in a town, community, or individual family can be judged very closely by the way they handle their own filth. If they have the antiquated open, insanitary privies, or no privies at all, and no screen doors or windows, they are about at the bottom of the scale. If they have screen doors and windows, they have moved up quite a bit; and if they have abolished privies altogether, or use sanitary privies and screens at their doors, they have passed the selfish stage and recognize that they are their brother's keeper. Where are you on this scale?

North Carolina State Board of Health Bulletin. September, 1913.

Red Cross Seals in 1913.

Running night and day, the presses of the American Bank Note Company are turning out for the American Red Cross and the National Association for the Study and Prevention of Tuberculosis, 100,000,000 Red Cross Christmas seals for use in the coming holiday campaign. If every one were sold for a penny, a million dollars would be realized for the anti-tuberculosis campaign in various parts of the country.

But, even the most enthusiastic of those on the firing line hardly expect more than one-half of these little bullets to be appropriated. Over 40,000,000 or $400,000 worth of seals were sold in 1912, however, a gain of nearly twenty-five per cent. over the previous year. Because of the growing interest in the anti-tuberculosis movement it is hoped that the 50,000,000 mark will be reached this year, netting $500,000 for the prevention of consumption.

A radical departure from previous seals in the shape and character of the design has been instituted this year. The seal is rectangular in shape, one and one-half inches wide and one inch deep. The center of the design will depict Santa Claus with his eight reindeer dashing across a field of snow, and the border will be a brilliant red and green decoration, the Red Cross emblem appearing on either side. The accompanying illustration shows the seal in black and white.

The design was drawn by C. J. Budd of New York, the well-known illustrator, who was awarded a prize of $100 for his drawing. The second prize $50 was awarded to R. Foster Worthley of New York and the third to Miss Hazel de Berard of Brooklyn. Miss Sara B. Hill of New York was given honorable mention.

Distribution of the seals will be started about October 1, and by December 1 it is expected that the entire 100,000,000 will be distributed. If more are needed, an additional supply will be printed. In addition to the seals themselves, advertising material to the amount of several million pieces is also being prepared. A particularly striking piece of advertising will be a small blotter for use as an envelope enclosure. The campaign this year will be organized in almost every city and town of the United States, and no less than 100,000 agents will give their services to the work.

Visiting Nursing.

"At the recent meeting of the National Organization for Public Health Nursing, held at Atlantic City, Miss Lillian Wald had the

following to say regarding visiting nursing and its relation to the public: "We like best to feel that visiting nursing is no longer associated in the mind of the intelligent public with only the pauper. It has emerged as a service for those who are sick in their homes and who are not to be classed with those entirely dependent on bounty, but whose incomes do not permit the engagement at full pay of the private nurse, or, for that matter, whose incomes do not permit the payment of the full cost of the bed in the hospital. It has been estimated that ninety per cent. of sick people are sick at home, and the visiting nurse associations have been for some years eager to identify their service with all classes of people who are sick at home, excepting those with incomes ample enough to engage the private nurse. It is said that less than twenty per cent. of the people in the United States have incomes of more than $1,000. The margin for sickness is necessarily too small to enable them to have complete care without resource to subsidized hospitals or subsidized nursing service. Because of the insufficient incomes of a large percentage of families where there is sickness, it is inevitable that means must be devised for giving them nursing care without injury to individual independence. Perhaps the only possible method for obtaining this is taxation. . . . It will probably be a long time before America responds to the social pressure for any form of state insurance that will include nursing for the sick. Until such time, people of very small or of moderate means can be cared for without any impairment of their dignity through their insurance, and perhaps in this way receive it."

International Hospital Record. August 20, 1913.

The Cost of Sickness.

"Preventable diseases today causes huge economic losses under two general groupings. Through illness they keep expert workers at home, thereby robbing them and the world of a part of their product. By death they cut short the careers of many persons who are in their economic prime. Think what the adding of but five years to the lives of men who now die at 45, 50 or 55 would mean in additional service and economic outputs—five more years of productive activity without the loss and waste involved in shifting their burdens to workers new and untrained. The present financial loss in this country through untimely deaths is only partly indicated by the five hundred million dollars paid out in death claims, etc., every year on life insurance policies. Dr. Allan J. McLaughlin of the United States Public Health Service recently stated in an address before the Association of Life Insurance Presidents, that in the matter of typhoid fever alone the number of preventable cases each year in the United States would probably reach 175,000 and that the deaths therefrom that could be avoided would total 16,200. He estimated the economic loss from this one disease at not less than one hundred million dollars annually. The report of the National Conservation Commission on National Vitality states that the economic waste from preventable deaths every year in the United States is about one billion dollars and that the economic waste from preventable illness is five hundred million dollars every year—making a total annual economic loss of one and one-half billion dollars, or more than enough to pay the entire expense of the Federal government."

Bulletin of the Ashveille, North Carolina Health Department, August 1913.

The Cost of Health.

"Every one has been interested in the wonderful work being done in Panama in the construction of the canal. Startling as have been the results of the work of the engineers and builders, the work of the Sanitary Department has been even more wonderful. In a region noted as the most unhealthful in the world, in which our predecessors, the French, were unable to succeed because they could not keep the workers alive, American Army surgeons, by the use of scientific facts known to all, have succeeded in lowering the death-rate among American residents far below that of our most favored American communities. According to Colonel Gorgas, the chief sanitary officer of the Canal Zone, the death-rate

for 1911 among 10,489 Americans was only 4.48 per thousand. While this result has been mainly due to the control of yellow fever and malaria, and while it is true that the American population consisted of picked individuals, largely of educated men and women in the prime of life, yet even with all these conditions recognized, the record is a remarkable one, and is probably without a rival. And all this, says Colonel Gorgas, has been accomplished at an expense averaging one cent per day for each individual. If this result can be secured at this cost in the center of a tropical jungle, what would not a similar expenditure do for our American cities? . . ."

Journal A. M. A.

Coöperative Public Health Work.

"Hon. F. W. Matthiessen, millionaire philanthropist, has again come to the fore in the tri-cities of La Salle, Peru and Oglesby, and submitted a proposition to the city councils of those cities which will be of untold benefit to every man, woman and child therein, enabling them to enjoy every protection from disease known to modern science. The acceptance of Mr. Matthiessen's proposition will place the Tri-Cities in the lead of any other community in the state so far as health and sanitation is concerned.

"Mr. Matthiessen's plan is that the Tri-Cities organize a health bureau with a health commissioner in general charge thereof, to embrace the cities of La Salle, Peru and Oglesby. In doing this there will be prevented a great deal of physical and mental suffering, which in the end will reduce taxes, as it is a well known fact that disease and death represent a high cost to any community.

"It is also provided that the health commissioner shall also conduct and maintain a department of research in public health matters for the advancement of hygiene and the prevention of disease. The position of health commissioner is to be absolutely non-political and such officer to be appointed by Mr. Matthiessen, and also asks that the city councils pledge their coöperation in carrying out this plan and that the health commissioner have full power to act under the ordinances which shall be passed by the three cities to make the health bureau effective.

"All of the expense connected with the establishment, operation and maintenance of this health bureau will be paid for by Mr. Matthiessen, but each city is to furnish to the health commissioner a sanitary inspector, detailed from the police department of each city, with full power and authority to carry out the orders of the health commissioner, the salary of this sanitary policeman to be paid for by the municipality.

"Oglesby has already accepted Mr. Matthiessen's magnanimous offer and La Salle and Peru will follow suit.

"It is probable that Dr. Ruediger, the present state health officer of North Dakota, will be appointed health commissioner."

Free Trader, Ottawa, Ill. November 5, 1913.

Trachoma.

"Investigations into the prevalence of trachoma have established the interesting fact that this disease is a veritable scourge among the Indians. The Public Health Service has demonstrated that 22.7 per cent. of 39,231 Indians examined were suffering from trachoma. The condition was most prevalent in Indian boarding schools, less in Indian day schools and least among reservation Indians above and below school age. It is obvious that the general ignorance of domestic hygiene, the occupation of one-room huts in place of the open tepees are factors in lessening the general health of the aboriginal American. With a lack of personal privacy, the common use of towels, wash basins, and bedding, and the general neglect of all measures of personal hygiene, the dissemination of trachoma is exceedingly simple.

"Dr. J. A. Stucky has awakened public interest in the trachomatous state of American mountaineers in eastern Kentucky. His pioneer work in establishing a clinic under difficult conditions served to arouse the interest of the Kentucky Board of Health and the United States Bureau of Public

Health. His general investigation of underlying conditions reveals a sad need of modern hygienic methods. The once vigorous natives, locked in their mountain homes, all but starving on their scanty crops, inadequately shod and clothed, dwell amidst open sewers, sharing with one another bed clothing, towels and disease. While Dr. Stucky has called attention to the trachoma problem and two trachoma clinics have been installed, the medical problem has scarcely been attacked. Here again is evident the value of social medicine.

"The lessons of sanitation, hygiene, dietetics, and modern medicine are called for. Homes must be visited, social workers are required to arouse discouraged souls and physicians must rally to the call for help. It is obvious that all attempts to lessen the spread of trachoma must be based upon an alteration of the present physical environment. The mere removal of tonsils and adenoids or the operative procedures called for by trachomatous sequelae will not suffice to prevent the further spread of this fearful disease of the eye."

Journal of Surgery. November, 1913.

Sanitation at Gettysburg.

The following brief account of some of the sanitary measures in force at the Veterans' Reunion at Gettysburg is clipped from an article in the *American Journal of Clinical Medicine* for September, 1913:

"The toilet accommodations consisted of 90 latrines, with two urine-troughs each; the total seating capacity of these being 3476. These latrines consisted of board walls, with flat, tarred-paper roofs, with ample air space between the roof and the side walls.

"Two pits were dug in each enclosure to a depth of 6 feet, where the ground water permitted. They were about 20 feet long and about 4 feet wide. The seats were arranged in two rows, and were of the box form, with hinged lids.

"Each morning, latrine-squads visited the latrines. The box-covers were tilted back, any refuse was brushed into the pits, and the contents were then liberally sprinkled with straw and crude oil. These were then fired, and as soon as the flames had died down sufficiently so as not to endanger the wooden seats, these large boxes were slammed back into place, so as to include as much as possible of the dense smoke under the covers.

"In addition to this, lime and crude oil were liberally used in the urinals. This very simple procedure, carried out systematically day after day, kept these latrines in an agreeable and sanitary condition. At no time, in spite of the large numbers of men in camp, and with the prevailing intense heat, was there anything disagreeable in connection with them.

"Flies were noticed only by their absence; and, as showing how this condition was appreciated by the veterans, I include a paragraph of a letter from one of these men:

"'On the 3rd of July, we missed one of our number, an old Welshman, 76 years old, with a broken leg, a bent body, supporting himself with a cane. We could not find him in any of the hospitals, nor could the boy scouts find him. As he was a sober man, the puzzle was great. Finally one of our mess found him sound asleep in one of the latrines. He said it was a cool place; no flies there!'

"There still remained to be disposed of 240 night-cans of refuse and urine. These were large galvanized covered cans, placed at intervals throughout the company streets, for the purpose of collecting the night urine and other refuse.

"These cans were collected each morning by teams, and were deposited at the central incinerator plant, which consisted of 6 regular pit incinerators, from 10 to 14 feet in diameter, and about 4 feet deep, placed in the center of the camp.

"These central incinerators certainly justified the dependence which the Army Medical Department places on this form of incinerator for the handling of camp-garbage, and only three were in operation at one time. As high as 2500 gallons of water-soaked sludge was consumed in one single incinerator in one day."